SCIENTIFIC AMERICAN SUPPLEMENT. No 998

Scientific American Supplement, Vol. XXXIX. No. 998.
Scientific American, established 1845.

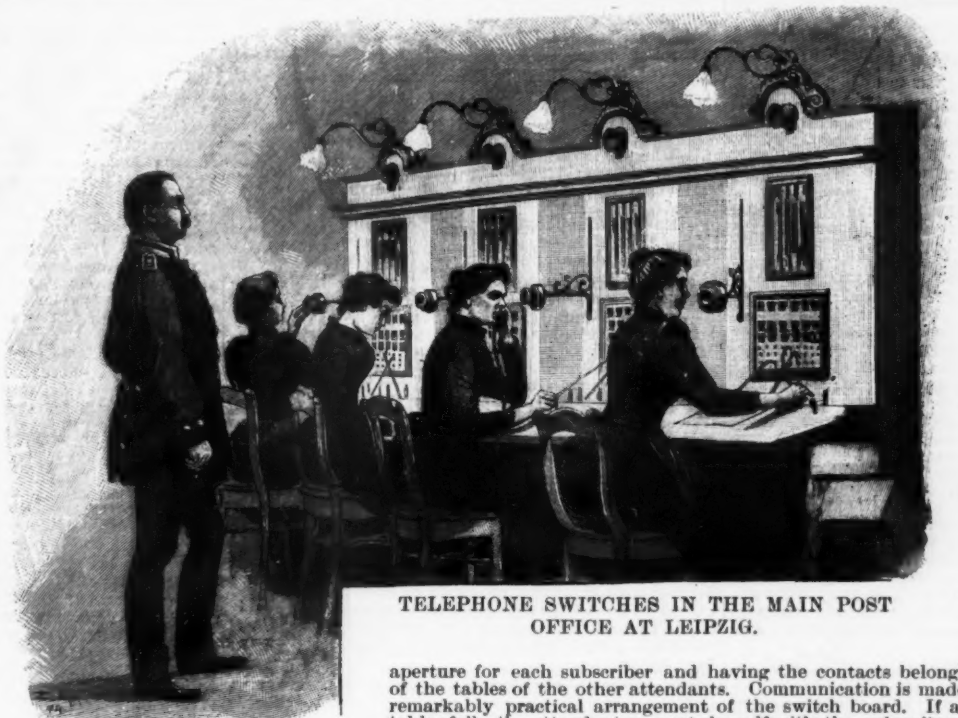
NEW YORK, FEBRUARY 16, 1895.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE TELEPHONE STATION IN THE MAIN POST OFFICE AT LEIPZIG.

EVEN now, when the discovery of the telephone in its useful form is scarcely twenty years old, the use of this apparatus, which lends wings to words, making it possible for them to fly countless miles in a minute, has spread in a most astonishing manner, becoming each day more universal. A few years hence it will be as common a means of communication among intelligent people as the pen.

An idea of the rapidity of the adoption of the telephone in Leipzig can be obtained from the statement that, at present, the number of private wires is 3,360, with a total length of 9,920 miles of wire, exclusive of the numerous outside connections. Many hundreds of wires run through the city on poles, and to these have lately been added 1,400 underground conductors in the form of 50 cables. All of these wires are connected with a large, light room in the main Post Office building, on Augustus Platz. There is the beating heart of the system, there the listening ear of the speaking world. No superfluous sound is heard in this room, where the noise of the step is lost in the soft linoleum, and only the peculiar tick and click of the apparatus, or a word here and there, betrays the nature of the work, performed so quietly by the uniformly dressed women answering the calls in low voices.



TELEPHONE SWITCHES IN THE MAIN POST OFFICE AT LEIPZIG.

As the former system proved inadequate for the rapidly increasing service, it was reconstructed by an enlargement, during the past year, of the Post Office building, in which was provided a high room with an overhead light, meeting all the requirements of hygiene, and furnished with all the latest improvements for telephone work. Here was placed the multiplex switch board, at which each attendant serves only a limited number of subscribers, but can immediately connect a subscriber with any other at any of the switch tables without leaving her own switch. The principle applied here consists in having a plug aperture for each subscriber and having the contacts belonging thereto connected with all of the tables of the other attendants. Communication is made very simple by means of the remarkably practical arrangement of the switch board. If a number drop at one of the tables falls, the attendant connects herself with the subscriber by inserting a metallic plug attached to a conducting wire, in the aperture to which the drop belongs. She then learns

THE NEW TELEPHONE ROOM IN THE MAIN POST OFFICE AT LEIPZIG.—DRAWN BY E. LIMMER.

the wishes of the person who called her, and makes the desired connection by inserting the second plug in the contact of the person to be called.

To prevent the premature breaking of the connection, there is a device for connecting a controlling battery when the receiver is taken from a subscriber's apparatus, which notifies the attendant by means of a clicking sound in the telephone, that the connection is not yet to be cut off. In the same way a battery, connected with the contacts, tells by a clicking in the receiver whether the wire is free or not.

A special room is provided for the long distance telephones, which have similar switches and are operated in the same manner as the local telephones. Furthermore, the names and addresses of all the subscribers are taken, and the length of time that a connection is kept open.

In regard to the business of the Leipzig office, it may be said that the number of daily conversations held over the local telephone averages 65,000, and those over the long distance telephone, 6,000; while Berlin has 22,070, Hamburg 8,995, and Dresden 3,267, Leipzig has, as we have stated, 3,360.—Illustrirte Zeitung.

PROTECTION FROM LIGHTNING.*

By ALEXANDER MCADIE.

AT the Aberdeen meeting of the British Association for the Advancement of Science Sir William Thomson made the remark, "If I urge Glasgow manufacturers to put up lightning rods, they say it is cheaper to insure than to do so."

This was the answer given by practical business men, concerned only with questions of profit and loss, to the foremost physicist of our time; and their answer will serve as fairly representing views widely held, founded upon the double belief that the risk from lightning is not so very great and the protection afforded by the present methods not sufficiently certain to warrant implicit confidence and justify the necessary expense.

The recent remarkable experiments of Dr. Oliver Lodge, in his lectures before the Society of Arts, opposing and to some degree directly contradicting the empirical rules of the Lightning Rod Conference, have given support to the belief that the protection was uncertain. Indeed, realizing that his work might be misinterpreted, Lodge has stated "an idea at one time got abroad that my experiments proved existing lightning conductors to be useless or dangerous; this is an entire misrepresentation. Almost any conductor is probably better than none, but few or no conductors are absolute and complete safeguards. Certain habits of lightning rod practice may be improved and the curious freaks or vagaries of lightning strokes in protected buildings are intelligible without any blame attaching to the conductor; but this is very different from the contention that lightning rods are unnecessary and useless. They are essential to anything like security."†

What Lodge's brilliant experimental work does show is that the momentum of an electric current cannot be overlooked in a lightning discharge. The old "drain pipe" idea of conveying electricity gently from cloud to earth must give place to the new proposition, based upon recent discoveries, that even draining off must be done in an appropriate way to be effective. To illustrate, the rocks and trees upon a mountain side may influence and determine the course of a mountain stream, but even a good sized channel would not suffice to carry off safely an avalanche, or control the path of a landslide; so with lightning. In the past four years we have learned, through the work of Hertz and others, that when an electric current flows steadily in one direction in a cylindrical wire its intensity is the same in all parts of the wire; but if the current be of an oscillatory character, i. e., a current which rapidly reverses its direction, the condition no longer holds, and if the alternations are very rapid the interior of the wire may be almost free from current. If lightning then be a discharge of an oscillatory character, it may happen that the current down the lightning rod would be only skin deep. The experiments of Tesla and Elihu Thomson with currents of great frequency of alternation and very high potentials open the door to systematic study of discharges such as the ordinary lightning flash. In daily work currents of this type are coming more and more into prominence, and the time is not far distant when the lightning flash will be studied as an electrical discharge of this character. Protection entirely adequate for such discharges will then be forthcoming. Indeed, the reasons why present methods occasionally fail are now understood, and the proper remedies apparent.

And first let us see whether it is cheaper to insure than to provide proper protection. Foreign countries, especially Germany, France, and Great Britain, have recognized the importance of obtaining reliable data concerning the loss of life and damage to property through lightning. Perhaps the work of the Royal Prussian Bureau of Statistics‡ gives the fullest and most detailed accounts of the damage done by lightning in Germany, and the relative injury. Statistics are available for the number of houses struck, the number of fires, the character of the roofing, soil, etc.

In 1891 the Weather Bureau issued to its observers instructions to report at the end of every month the names, with corroborative dates and places, of all persons killed by violent windstorms, tornadoes, and lightning. During 1890 somewhat similar statistics had been gathered, but the returns were less systematically arranged. In preparing the Weather Bureau lists, observers were directed to examine all daily papers published in their respective cities, consult all local authorities, and make inquiry if necessary. Naturally, where dependence was had upon newspaper items, there resulted much duplication, but in verifying names and dates the duplicates quickly appear and exaggerated reports are easily confined to proper limits.

From the Weather Bureau records which have been tabulated, it appears that in the United States, for the four years 1890-93, 784 lives were lost, an average of 196 lives per year.

It is also evident that these lives were practically all lost in five months—April to September—and that in June and July the maximum death rate occurs.

The Weather Bureau records unfortunately do not give information as to the extent of damage to property. To get at something like a fair commercial estimate of the destruction of property by lightning, I have made use of the "Chronicle Fire Tables" for the eight years 1885-92. It is hardly necessary to remark that these tables are compiled from the reports of the fire departments, insurance companies, and the reports of fires in the public press, and represent a high degree of accuracy.

From information contained in these volumes, the following tables have been compiled:

FIRES CAUSED BY LIGHTNING.

Year.	Number of fires.	Loss on original risk.
1885 to 1890, inclusive	2,220	$8,386,826
1891	457	1,355,525
1892	839	2,921,484

Or, in eight years, ending 1892, in the United States, and for the most part east of the Rocky Mountains, 3,516 fires, with a loss of $12,663,835.

It is very evident, therefore, that the damage done by lightning is no inconsiderable matter to be lightly passed over or turned off by replies such as the one given by the Glasgow manufacturers. It is certainly worth while to erect the proper protective apparatus.

The following table shows the number of barns, stables, granaries, churches, and dwellings set on fire by lightning during the years 1890, 1891, and 1892:

Year.	Barns, stables, and granaries.	Churches.	Dwellings.
1890	363	29	121
1891	290	11	78
1892	495	29	177

During nine years ending 1892, 2,335 barns, 104 churches, and 664 dwellings have been struck by lightning.

The question has often been raised whether there exists a periodicity in the number of lightning strokes. Statistics must cover a period of at least twenty years before an answer to this question can be given, but it is interesting to compare the number and kind of buildings struck for the last two years of which we have record.

	1891.	1892.
Barns, granaries, and stables	290	495
Churches	11	29
Country and general merchandise stores	5	6
Dwellings and tenements	78	177
Electric light stations	1	2
Grain elevators	2	4
Grain fields	1	..
Grain, hay, and straw in stack	10	12
Ice houses	4	4
Lighthouses and life-saving stations (no other source of fire reported)	2	...
Livery stables	4	4
Lumber yards	2	1
Oil refineries	2	2
Oil tanks	2	22
Railroad depots	5	7
Telegraph and telephone offices	2	3

It is of particular interest to study the geographical distribution of the dwellings and barns struck in these two years. There are some notable increases in certain States, the reasons for which are not at present discernible. Attention is directed to the figures in boldface type.

State.	Barns.		Dwellings.	
	1891.	1892.	1891.	1892.
Connecticut	9	**23**	6	**16**
Delaware	4	5	..	...
Illinois	17	7	7	**12**
Indiana	31	38	7	9
Iowa	19	6	..	...
Kansas	1	2	..	...
Kentucky	3	4	..	...
Maine	21	23	7	**16**
Maryland	12	8	..	**6**
Massachusetts	12	15	8	**12**
Michigan	26	**70**	..	**18**
Minnesota	7	5	4	6
Mississippi	1	...	..	...
Missouri	2	1	2	3
Nebraska	1	...	..	...
North Carolina	2	3	..	2
New Hampshire	2	2	..	...
New Jersey	14	**30**	3	7
New York	30	**117**	5	**23**
Ohio	26	26	6	4
Oregon	2	...	..	...
Pennsylvania	29	**73**	3	**23**
Rhode Island	1	4	..	2
South Carolina	3	...	..	...
South Dakota	3	3	..	...
Texas	4	7	..	...
Virginia	4	...	..	2
Wisconsin	6	**11**	2	3

According to the statistics of the German bureau previously referred to, the frequency of lightning stroke varies somewhat with the character of the land. Thus, in their investigations it was found that in flat lands 400 to 540 buildings were struck out of 1,000,000, the rate varying in different localities.

The nature of the material used for roofing has also been considered. Classifying the various materials under the general heads "hard" and "soft," the German investigators found for ten years (1873-83) for Schleswig-Holstein, that of all the buildings struck, 9 per cent. of those having hard roofs and 68 per cent. of those having soft roofs were set on fire. The nature of the building and the purpose for which it is used will, as we readily see also in our own statistics, influence the liability to stroke and fire.

One interesting point which appears to be shown by statistical studies of lightning stroke is the decreased liability to accident in thickly settled communities.

It may be said in general, that the risk in the country is five times greater than in the city. For ordinary dwelling houses, not unduly exposed in city blocks, lightning rods are hardly necessary, a very considerable protection being afforded by the tin roofing, numerous cornices, gutters, etc. The geological, as well as the topographical conditions, may have some influence upon the frequency of lightning stroke. According to the authority already quoted, if 1 represents the frequency of lightning stroke in a chalk formation, 2 will represent the liability for marl, 7 for clay, 9 for sand, and 22 for loam.

With regard to trees, the oak is most frequently, and the beech least frequently, struck. The values are something like, if 1 represents the frequency for the beech tree, 15 for pines, other trees generally averaged at 40, and 54 for oaks. Trees struck are most generally those standing in the clear or on the edge of forests, and in height averaging from 16 to 20 meters (53 to 66 feet). The trunk appears to be struck about three times as often as the boughs, and generally the stroke seems to travel to the ground. Only in three out of a hundred cases did it jump to other trees.

Mr. Symons,* in his paper on thunderstorms, instances 16 trees struck. About one-third of these were elms, with the oak, ash, poplar in order following, and one case each of crab lime and willow.

It is interesting to recall at this point the record made by Hugh Maxwell as early as 1787, that the elm, chestnut, oak and pine were often struck, the ash rarely, and the beech, birch, and maple never. This last, however, is not true. Indeed, it is not altogether plain just why some trees escape while others suffer. Capt. Maclear,† discussing the action of lightning during a thunderstorm on June 6 and 7, 1889, found a great number of trees struck within a radius of 4 miles, and set to work to discover if possible the cause of the selection of these particular trees. "For contrary to general expectations," he says, "they were not the highest nor the most prominent in their immediate vicinity." A cottage, a haystack, 2 poplars, a spruce, fir, and 5 oaks, in different places, were struck within this confined area.

The storm passed in a northwest direction with southeast wind, and it is apparent that the objects struck lie nearly in a line northwest and southeast, 3 miles in length. "The spruce was very prominent on the southern brow of the hill, with two arms nearly in line with the stem; one arm was thrown to the ground and the other blown down. At the juncture of the arms there was a great deal of turpentine which was thoroughly blackened." Hence, it is assumed that the prominence of the tree made it the best communication to earth, and that the collection of turpentine was raised to explosive temperature and split the tree, but a like good reason does not appear for the other objects struck. On the next day 6 oaks, a chestnut, and an ash, in various positions within one-half mile of a pond, and on the slope of ground near the pond, a young fir, and 3 young oaks; one-half mile south of Cranleigh 4 oaks; on Cranleigh Common an oak; and 1 mile northwest a chimney, a stable, and an oak (struck also on the day before) and a single oak occupying a fairly prominent position on the slope of high hills, 2½ miles northeast.

This last tree was struck just before the rain commenced and was split; the other trees struck during the rain were only scored. "Hence," concludes Maclear, "it is not easy to see the cause of selection, for these trees were not the most prominent, nor were they on the highest ground in the vicinity, the only feature the groups possessed in common being that they were all either near ditches which were full of running water or else near temporary courses taken by the deluge of water from the higher to the lower ground. The most puzzling case is that of the young fir tree and 3 young oaks in the middle of the copse near the pond. They were not higher than the other trees on the copse, but there certainly was a temporary water course close to them; other trees, however, stood equally close to water. . . . Another curious case is that of the stable struck, which was overshadowed by tall elms, where it might have been supposed that these would have taken the stroke."

Some statistics of the damage done by lightning stroke in Belgium ‡ in 1889 may be appropriately inserted here. Of 324 lightning flashes, 2 struck lightning rods; 123 struck buildings, setting 36 on fire; 16 struck persons; 96, trees; 81, telegraph and telephone lines; and others, miscellaneous.

In other statistics we find that of 18 deaths due to lightning: 1 occurred within a dwelling, 11 out of doors and 6 under trees. Contrasted with the cases of death resulting from lightning stroke, let us look at 43 cases of persons struck, with results not necessarily fatal, and we find that 20 of these were indoors, 23 out of doors, including 4 under trees. No records sufficiently extended and authentic are available to ascertain what proportion of persons struck by lightning are killed outright. I know of but one record, and in that of 212 persons struck 74 were killed. This question, which is of the greatest interest, is referred to again under the last of the rules given further on for the protection of life.

One of the peculiar and most common characteristics of the action of lightning is the tearing off or throwing

* From the Circular of Information, issued by the Weather Bureau, Department of Agriculture.

† Page vi. "Lightning Conductors and Lightning Guards."

‡ Beitrage zur Statistik der Blitzschlage in Deutschland; von Dr. Hellman, Berlin, 1886.

* Also Appendix E. "Report of Lightning Rod Conference."

† "Quart. Journ. Met. Soc.," 1890, p. 220.

‡ Evrard and Lambotte. Ciel et Terre, 1891; No. 7.

effect. This, as we shall see further on, is just what might be expected from discharges of great frequency of alternation. Some interesting statistics are given by Parnell* on the mechanical tearing off and disruptive effects of lightning as distinguished even from the heat effects. He records 1,147 cases. Of these, 224 do not permit a determination of the character of the work done by the stroke of the remaining 923.

	Mechanical work.	Heat.
Persons and animals	52	79
Cloths, carpets, canvas, woolen, linen and cotton goods	88	79
Masonry of all kinds	416	2
Glass, china, earthenware	82	5
Metal	206	173
Wood	254	98
Trees	63	4
Ground	60	...
Thatch, straw, etc	....	11
Gunpowder	....	15
Gas	....	19
Total	1,221	485

Colonel Parnell gives, furthermore, the details in 278 cases to show the existence of an upward direction in the force of the stroke.

This, and the statement that "probably few persons are aware that lightning strokes are more apt to bend or break metal than fuse it," are in the light of the investigations of the past three years into the character of the lightning flash, easily comprehensible. A lightning flash being a break in the air (i. e., the dielectric) when the electrical strain exceeds a certain value, determined by several variables, the strongest mechanical effect may be found in any direction, upward or downward. Speaking popularly, flashes may go from cloud to earth, earth to cloud, or from cloud to cloud to earth.

II.

Beyond doubt, Franklin proved his case that lightning rods were efficacious in the protection of buildings. Buildings with conductors when struck by lightning suffered little damage compared with those without protectors.

The chief defects likely to occur are blunted points and breaks in the continuity of the connection. The function of a lightning rod is twofold; first, that of conducting the charge to earth, and second, the prevention of a disruptive discharge by silent neutralization of the cloud electrification. The latter explains why a rod terminates in a point and likewise why points in good connection with the ground are always desirable upon buildings. Indeed, points are somewhat like small water pipes connected with a large reservoir. If you have enough of them and a sufficient time, you may drain the largest reservoir. Furthermore, when some sudden rise or flood occurs in the reservoir, these minute drains may be of service in keeping the height of the water down.

In the case of lightning the points are the small escape pipes, the layer of air between cloud and earth, the retaining wall, and the cloud electrification—or charge—the overflowing and destructive element. A large conductor, be it rod or tape, on the other hand, is more like a large main or waterway, which has its gate shut until the flood is imminent. Then the gate is suddenly opened and we try to compel the torrent to keep to the provided path. We trust in its ability to safely hold the flood. Generally it does. In perhaps nine cases out of ten, the lightning conductor, if it be such a one as we will describe later, does carry the flash to earth; but there are cases where the discharges have been heavy and overflows have resulted. To carry the lightning flash "the lightning conductor should offer a line of discharge more nearly perfect and more accessible than any other offered by the materials or contents of the edifice we wish to protect." To prevent the discharge "the conductor should be surrounded by points." These quotations are from the report of the Lightning Rod Conference.

The statement that lightning always follows the path of least resistance, as commonly understood and stated, needs modification. True it is that when the air is strained by being subjected to the electrifications of cloud and earth, the weakest spot gives away first, and this is apt to be in line with some small elevated knob or surface, but it is equally true, and is perhaps the more general case, that when a really vigorous disruptive discharge does occur, it is somewhat, as Dr. Lodge aptly puts it, like an "avalanche." As a matter of fact, we find from the study of actual cases where buildings have been struck, that lightning often disregards entirely metallic surfaces and points. What we should first know is, whether the condition is to be one of "steady strain"† or "impulsive rush"† discharge. In the case of "steady strain," the metal is apt to influence the path of discharge; in the case of an "impulsive rush" discharge, even points seem to lose their efficiency and become of little use.

In a letter ‡ of an old British admiral there occurs a description of his being called upon to approve some specifications for a lightning conductor to be erected on a certain lighthouse. He was himself a believer in the "surface" theory of Harris; but thought that, to make sure, he would go and consult his friend Faraday. Faraday, who saw only the question of conductivity in the problem, said very positively that the solid rod was better than the tube (which gives greater surface with less copper), and that solid volume was everything, superficial area nothing. Moreover, if Harris says otherwise, "then he knows nothing whatever about it." The admiral straightway approved the solid rod conductor for the lighthouse. Within two or three days he met Harris, and bringing up the question was told by Harris "surface area is most important, and if Faraday says otherwise, then he knows nothing whatever about it!"

Up to a certain point Faraday was right; a copper rod an inch thick is capable of carrying almost any flash of lightning, and is, undoubtedly, a great protector, but if, as we have reason to believe, the core is seldom given a chance to carry the current, why have it? The views of Sir W. Snow Harris, based as they were upon close study of many thousand cases of lightning action, are finding in the experiments of to-day the confirmation so long needed.

While not going into details regarding this question of the shape of the rod, let us emphasize the fact, so recently brought out, that if an electric current flows steadily in one direction in a cylindrical wire, its intensity is the same in all portions of the wire, as shown by Hertz, but that with a current of an oscillatory character, i. e., a current which rapidly reverses its direction, this condition no longer holds, and if the direction is altered very rapidly, the interior of the wire, in our case the lightning rod, may be almost free from current.

In 1882 appeared the report of the Lightning Rod Conference; in many respects the most important contribution to the literature of the subject yet made. While so many foreign governments, and in particular France, had by means of officially constituted boards taken a governmental interest in the protection of the people from the dangers of lightning, the English-speaking people of the world, aside from the few directions officially issued for the protection of magazines and lighthouses, remained without any authoritative utterance upon the subject; and while this conference itself did not have strictly official sanction, it carries, from the character of its make-up, a weight certainly as great, if not greater, than an official board. It was simply a joint committee of representative members of the Institute of British Architects, the Physical Society, the Society of Telegraph Engineers and Electricians, the Meteorological Society, and two co-opted members. As might be anticipated from such auspices, the report is an excellent one, and must stand for years as the embodiment of the most widely gathered information and well-considered decisions. The report is emphatically one based upon experience.

The famous free-for-all discussion which occurred at the British Association meeting in 1888, so far as our judgment goes, simply proved that the decisions of the conference could not at present be disregarded. As the president of the meeting, Sir William Thomson, said, we have "very strong reason to feel that there is a very comfortable degree of security, if not of absolute safety, given to us by lightning conductors made according to the present and orthodox rules."

There are one or two further features to which attention may be called. There are some very prevalent misapprehensions with regard to lightning. For example: that it never strikes twice in the same place; that the most exposed place is always struck; that a few inches of glass or a few feet of air will serve as a competent insulator to bar the progress of a flash that has forced its way through a thousand feet of air, etc. These are alluded to in the following general directions.

III.

1. Erection of rods. Few questions have been so thoroughly discussed from practical as well as theoretical standpoints as that of the certainty of the protection afforded by properly constructed lightning rods. All barns and exposed buildings should have lightning rods. Ordinary dwelling houses in city blocks have not the need for rods that scattered houses in the country, and especially if on hill sides, have.

2. Use a good iron or copper conductor. If the latter, one weighing about 6 ounces to the foot, and preferably in the form of tape. If iron is used, and it seems to be in every way as efficient as copper, have it in rod or tape form and weighing about 35 ounces to the foot. "A sheet of copper constitutes a conductive path for the discharge from a lightning stroke much less impeded by self-induction than the same quantity of copper in a more condensed form, whether tubular or solid." (Sir William Thomson.)

3. The nature of the locality will determine to a great degree the need of a rod. Places apart but a few miles will differ greatly in the relative frequency of flashes. In some localities the erection of a rod is imperative; in others, hardly necessary.

4. The very best ground you can get is, after all, for some flashes but a very poor one; therefore, do not imagine that you can overdo the matter in the making of a good ground. For a great many flashes an ordinary ground suffices, but the small resistance of one-tenth ohm for an intense oscillatory flash may be dangerous. Bury the earth plates in damp earth or running water.

5. "If the conductor at any part of the course goes near water or gas mains, it is best to connect it to them. Wherever one metal ramification approaches another it is best to connect them metallically. The neighborhood of small bore fusible gas pipes and indoor gas pipes in general should be avoided." (Lodge.)

6. The top of the rod should be plated or in some way prevented from corrosion and rust.

7. Independent grounds are preferable to water and gas mains.

8. Clusters of points or groups of two or three along the ridge rod are recommended.

9. Chain or linked conductors are of little use.

10. Area of protection. Very little faith is to be placed in the so-called area of protection. The committee that first gave authority to this belief considered that the area protected by any one rod was one with a radius equal to twice the height of the conductor from the ground. Many lightning rod manufacturers consider that the rod protects an area of radius equal to the height. The truth is that buildings are struck sometimes within this very area, and we now hold there is no such thing as a definite protected area.

11. Return shock. Some uncertainty exists on this point. The so-called "return stroke" is caused by the inductive action of the charged cloud on bodies within its influence, and yet some distance away from the place of the direct discharge. As explained by Lord Mahon, who first called attention thereto, the sudden return of the body charged inductively to a neutral condition, following the equalization at some distant place, is the cause of the return shock. We are beginning, however, to see more clearly into the character of the stress in the dielectric, preceding and during flashes, and it is only a question of time before the use of this term, "return shock," will be abandoned. Of far greater import are the terms "recoil kick" and "alternative path," as shown experimentally by Lodge to exist.

12. Upward motion of stroke. There is no reason to doubt that the discharge takes place sometimes from earth to cloud. That is to say, that while we now consider a lightning flash as something like the discharge of a condenser through its own dielectric, made up of excessively frequent alternations, say something like 300,000 times per second, the spark, or core of incandescent air, may seem to have had its beginning at the earth's surface. That is to say, the air gap breaks down first at a point near the earth.

13. Indifference of lightning to the path of least resistance. Nearly all treatises upon lightning up to within very recent times assumed that lightning always followed the path of least resistance. "It is simply hopeless to pretend to be able," says Lodge, "to make the lightning conductor so much the easier path that all others are out of the question." The path will depend largely upon the character of the flash.

14. Any part of a building, if the flash be of a certain character, may be struck, whether there is a rod on the building or not. Fortunately, these are exceptional instances. The great majority of flashes in our latitudes are not so intense but that a good lightning rod, well earthed, makes the most natural path for the flash. We have many instances, however (not to be confounded with cases of defective rods), where edifices, seemingly well protected, have been struck below the rods.

15. Paradox of paradoxes, a building may be seriously damaged by lightning without having been struck at all. Take the famous Hotel de Ville of Brussels. This building was so well protected that scientific men pronounced it the best protected building in the world against lightning. Yet it was damaged by fire caused by a small induced spark near escaping gas. During the thunder storm, some one flash started "surgings" in a piece of metal not connected in any way with the protective train of metal. The building probably did not receive even a side flash. This is, therefore, a new source of danger from within, and but emphasizes the necessity of connecting metal with the rod system.

16. Lightning does sometimes strike twice in the same place. Whoever studies the effects of lightning's action, especially severe cases, is almost tempted to remark that there is often but little left for the lightning to strike again. No good reason is known why a place that has once been struck may not be struck again. There are many cases on record supporting the assertion.

17. As lightning often falls indiscriminately upon tree, rock, or building, it will make but little difference sometimes whether trees are higher than adjoining buildings.

18. It is not judicious to stand under trees during thunderstorms, in the doorway of barns, close to cattle, or near chimneys and fireplaces. On the other hand, there is not much sense in going to bed or trying to insulate one's self in feather beds. Small articles of steel, also, do not have the power to attract lightning, as it is popularly put, or determine the path of discharge.

19. Unnecessary alarm. Just in advance of thunderstorms, whether because of the varying electrical potential of the air or of the changing conditions of temperature, humidity, and pressure, and failure of the nervous organization to respond quickly, or to whatever cause it may be due, it cannot be denied that there is much suffering from depression, etc., at these times. It is, perhaps, possible that these sufferings may be alleviated. Apart from this, many people suffer greatly from alarm during the prevalence of thunderstorms, somewhat unnecessarily, we think. Grant even that the lightning is going to strike close in your vicinity. There are many flashes that are of less intensity than we imagine, discharges that the human body could withstand without permanent serious effects. Voltaire's caustic witticism that "there are some great lords which it does not do to approach too closely, and lightning is one of these," needs a little revision in these days of high potential oscillatory currents. Indeed, the other saying, "Heaven has more thunders to alarm than thunderbolts to punish," has just so much more point to it, as it is nearer the truth. One who lives to see the lightning flash need not concern himself much about the possibility of personal injury from that flash.

20. Finally, if you should be in the vicinity of a person who has just been struck by lightning, no matter if the person struck appears to be dead, go to work at once and try to restore consciousness. There are many cases on record proving the wisdom of this course; and there is reason for believing that lightning often brings about suspended animation rather than somatic death. Try to stimulate the respiration and circulation. Do not cease in the effort to restore animation in less than one hour's time. For an excellent illustration of a case of severe lightning shock and recovery, due, it would seem, to prompt action by the medical gentlemen present, all who are interested may consult the Medical News, August 11, 1888. A number of cases corroborative of this view are on record in various medical journals.

IV.

A practical application of the efficiency of lightning conductors will now be considered. On June 5, 1885, the Washington Monument, at Washington, D. C., at that time the highest edifice in the world, was struck by lightning. The barograph curve shows the fluctuation in pressure about the time of the occurrence of the stroke, 3.15 P. M. The storm itself was, as usual, a secondary depression in the southeastern or southern quadrant of a "low" area, and at Washington resulted in a high forenoon temperature, with a maximum of 90° Fah. about noon, with fresh southerly winds, veering to southwest at noon; to northwest at 1.23 P. M., to northeast at 1.40 P. M., and backing to northwest at 1.42 P. M.; to east at 2.20 P. M.; to northwest at 2.37 P. M., and veering to northeast at 2.40 P. M., from whence it shifted to southwest at 3.02 P. M.; to northwest at 3.10 P. M., and at 7 P. M. was blowing steadily from the north. The first thunder was heard at 1.07 P. M., and rain began at 1.28 P. M., ceasing at 2 P. M., commencing again at 2.20

* "Quart. Journ. Met. Soc.," vol. vi., 1885. See also Col. Parnell's book.

† Terms used by Professor Lodge.

‡ See report of Lightning Rod Conference.

P. M., and ending at 3.05 P. M. Thunder continued at frequent intervals to 3.50 P. M. The rain was at times heavy, and hail fell in the northern part of the city. Amount of rainfall at Signal Office, 0·61 inch.

Col. Casey, United States Army, the engineer in charge of the construction of the monument, requested Profs. Rowland, Newcomb and Mendenhall to examine the part struck and suggest what precautions should be taken to insure the safety of the monument. It is proper to remark that the monument had been for all practical purposes finished and had already experienced storms of seemingly greater violence.

From the letter* of the commissioners charged with the completion of the monument, we find that "a considerable amount of unexpected work" was performed in the erection of rods and points to protect the obelisk from lightning. "The lightning protectors, as established for the monument, were commenced in January, 1880, and were finished in January, 1885," practically the date of completion of the monument. The elevation of the solid aluminum pyramid (which weighs 100 ounces and is 8·9 inches high and 5·6 inches square at base, with angle at the vertex of 34° 48') is 555 feet (169·16 meters).

The conductors consist of the four hollow wrought iron Phenix columns, supporting the elevator machinery. "The bottoms of these four columns rest upon and are bolted to cast iron shoes, standing upon the floor of the large drum pit, . . . and the shoes are connected to ¾ inch soft copper rods, led to the bottom of a well in the center of the foundation. This well is 32 feet 10 inches in depth below the bottom of the drum pit and 15 feet 8 inches below the bottom of the masonry foundation, and the water stands in it permanently 2 feet 8 inches above its bottom. After the copper rods were inserted the well was filled up with clean, sharp sand for a depth of 15 feet 8 inches, or up to the level of the bottom of the old rubblestone foundation of the monument. These four columns, so arranged at their bases, and always projecting above the top of the shaft, were continually lengthened as the building of the shaft progressed, and for the five summers during which the masonry was in progress acted as the lightning conductors of the edifice. No disruptive discharge of electricity was experienced during those years."

When the marble pyramidion was completed, December, 1884, these four columns were within this marble covering, and from the extremity of each column a copper rod ¾ inch in diameter was run to the top stone and there united in a copper rod 1½ inches in thickness, which passed vertically through the cap stone and was screwed into the solid aluminum pyramid.

The conductors "when tested, gave an electrical resistance of 0·1 ohm from the tip of the terminal to the copper rods at the base, and 2·2 ohms for the ground connections, making a total resistance of 2·3 ohms for the conductor. The system was entirely completed and connected on January 20, 1885."

On April 5, 1885, during the passage of a heavy thundercloud over the monument, at least five immense sparks or bolts of electrical light were seen, within a period of twenty minutes, to flash between the terminals and the cloud without audible sound to the observers. A careful examination of the conductors and shaft after this phenomenon failed to reveal any effects from these discharges.

On June 5, however, during the thunderstorm described above, a disruptive discharge was seen to pass between the summit of the pyramidion and the cloud. Upon examining the structure, a crack was discovered in the stone on the north face of the pyramidion just under the top stone, extending through the block in a line nearly parallel to the northeast corner and about 8½ inches from it. The fragment was pressed outward about ¾ inch at its bottom, chipping a small piece off the lower corner of the top stone into which it was locked, and was easily forced back to place and was bolted to the solid stone from which it had been torn.

The recommendations of the gentlemen above named, who were asked to make a careful examination, were, in short, that the interior conductors should be connected "with a system of rods and a greater number of points, to be located upon the exterior of the pyramidion." Four one-half inch copper rods were fastened by a band to the aluminum terminal and led down the corners to the base of the pyramidion, and then through the masonry to the columns.

"As these exterior rods are each over sixty feet long, they are also connected at two intermediate points of their lengths with the iron columns by means of copper rods one-half and three-quarters inch in diameter, respectively, furnishing sixteen rods in all, connecting the exterior system of conductors with the interior conducting columns. Where the exterior rods upon the corners cross the eleven highest horizontal joints of the masonry of the pyramidion, they are connected to each other all around by other copper rods sunk into those joints. All of these exterior rods, couplings, and fittings are gold plated, and are studded at every five feet of their lengths with copper points three inches in length, gold plated, and tipped with platinum. There are two hundred of these points in all."

Eight years have now passed since the alterations were made and the monument stands uninjured. Unquestionably, standing, as it does, 555 feet high, in the center of flat, well-watered ground, it constitutes a most dangerous exposure for lightning flashes. No better illustration of the value of lightning conductors can be asked.

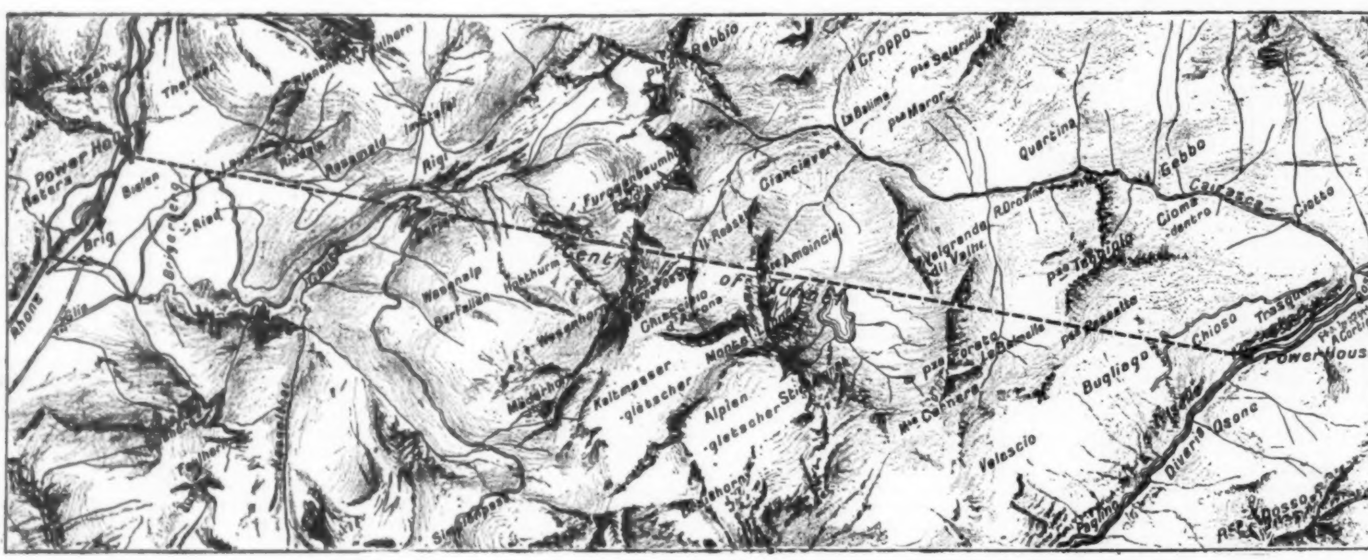
* Senate Ex. Doc. No. 6, 49th Congress, first session.

[FROM THE ENGINEER.]

THE SIMPLON TUNNEL.—I.

THE company which has been formed to construct a tunnel through the Pennine Alps under Monte Leone has just issued a descriptive report, in which it mentions the difficulties it expects to encounter, and explains the manner in which it hopes to overcome these difficulties. This statement has been submitted by the Swiss government to a committee of engineers, composed of Messrs. G. Colombo, Francis Fox and C. J. Wagner, together with all plans and documents the company possesses relating to the work, and their criticism of the project accompanies the report.

The road over the Simplon Pass from Brigue to Domo d'Ossola was commenced by Napoleon I, in 1801, and finished in 1806; and at its highest point it is 6,500 feet above the sea. Many projects have been made for connecting the railway which runs from Geneva, via Martigny to Brigue, with that which starts at Domo d'Ossola, and passes through Vogogna to Novara, on the main line connecting Turin with Milan. The company's report gives a list of these projects, dividing them into three classes. The first class comprises schemes in which tunneling is avoided as much as possible, and the line is taken up inclines of 5 or 6 per cent., by zigzags, to a tunnel near the summit. In the second class of projects, a tunnel at an intermediate height is proposed, but the steep inclines are still indispensable; while the third class consists of those requiring a tunnel at least ten miles long, and starting practically at the level of the lines which it connects.



MAP SHOWING PROPOSED LINE OF THE SIMPLON TUNNEL.

The company decided that in order to be able to compete with neighboring Alpine lines and receive a return for the capital invested, the last class of projects were the only reasonable ones. It examined those that had been made, and eventually decided on the line shown on Fig. 1 above. In this design, the tunnel starts half a mile above the new station of Brigue, on the left bank of the Rhone, and passes through the mountain in the direction of N.W.—S.E. Its southern extremity is on the left bank of the Diveria, and its length is 12 miles 460 yards. At the northern end—see Fig. 2—it is 2,255 feet above the level of the sea, at the center 2,314 feet, and at the southern end 2,080 feet. The line of the frontier between Switzerland and Italy crosses the axis of the tunnel at right angles, just above the center. At this point the distance from the tunnel to the surface of the ground is 7,000 feet. The altitude of the northern end was fixed by the high water mark of the Rhone; while at the southern end, as the tunnel comes out just below Iselle and the line has to follow the valley of the Diveria, it was thought advisable to keep it at the same level as the existing road.

The position of the ends being fixed, and the southern end being 175 feet lower than the northern, it was decided that the latter should have the least incline which would allow the water to run off freely, and a gradient of two per mil was chosen. It was then found that the southern half would have an inclination of seven per mil. The tunnel will commence and finish with short curves; the radius of that on the north being 365 yards and that on the south 328. For 11 miles and 1,640 yards it will be in a straight line. The length of the northern, two per mil incline, will be 5 miles 1,100 yards, and that of the southern, seven per mil, 6 miles 563 yards; the intermediate 547 yards being level. As a basis of comparison, the report then gives the following particulars of the different tunnels which pass through the Alps:

	Mont Cenis.	Gothard	Arlberg	Simplon.
	m. yds.	m. yds.	m. yds.	m. yds.
Length of tunnel	7 1,734	9 549	6 640	12 460
Altitude, northern or eastern end	3,766 ft.	3,639 ft.	4,274 ft.	2,255 ft.
" southern or western end	4,164 ft.	3,757 ft.	3,996 ft.	2,080 ft.
" highest point	4,248 ft.	3,778 ft.	4,300 ft.	2,314 ft.
Maximum gradient in tunnel per mil	22	5·82	15	7
Max. altitude of ground above axis	9,676 ft.	9,886 ft.	6,062 ft.	[illegible]
" thickness of mountain above tunnel	5,428 ft.	5,598 ft.	2,362 ft.	7,000 ft.
" temperature of rock (Fahrenheit)	85 deg.	87 deg.	65 deg.	104 deg.

(1) Cross Sections.—The Simplon Tunnel will differ from all others which have been made through the Alps in that it will eventually consist of two parallel tunnels 56 feet apart, and each for a single line of rails. Each tunnel is to have a minimum sectional area of 229 square feet in the clear. The width in the clear is to be 14 feet 9 inches at the level of the sleepers and 16 feet 5 inches at 6 feet 6 inches above them. The height from the top of the sleepers to the key of the arch is to be 18 feet.

As will be seen by Fig. 3, five different cross sections have been designed, to be adopted according to the nature of the ground which is being traversed. They are as follows: (A) In compact rock with regular strata; no lining required. (B) In rock requiring a slight lining, and where the strata are irregular. Side walls and arch in ashlar, 14 inches thick. (C) In ground where there is a medium pressure; side walls in ashlar, arch in dressed stone 20 inches thick. (D) In ground where there is a strong vertical pressure; side walls in coursed masonry; dressed stone arch, 24 inches thick. (E) In ground which is in a state of decomposition, and where there is strong lateral pressure; side walls in coursed masonry; an invert 16 inches thick and arch 24 inches thick in dressed stone.

At intervals of 110 yards, on one side only, there will be refuges 6 feet 6 inches wide by 7 feet 6 inches high. At every 1,100 yards, instead of these niches, there will be a room 9 feet 10 inches wide and deep, and 10 feet 2 inches high, serving for signals and lamps. Besides these, four larger rooms will be constructed, to serve as stores for platelayers' tools, etc. These will be placed at equal distances apart, and will be 13 feet 2 inches wide, 10 feet 2 inches high and 19 feet 8 inches deep. The two headings are to be 12 feet 1½ inches wide by 12 feet 7½ inches high above the sleepers. The parallel gallery will be lined wherever it is considered necessary. It will contain the principal channel for carrying off the water, and all the drainage from the main tunnel will be led into it. To allow trains to cross, there will be a siding a quarter of a mile long in the middle of the tunnel.

(2) Section of Strata.—At the Gothard Tunnel the more recent formations are placed beside the older fan-shaped strata of the central mass. This is the case on the south as well as on the north, outside the older zone of the Finsteraarhorn; while at the Simplon the series of strata agree with their ages, going from south to north. The oldest rock is on the south, and consists of calcareous mica-schist, covered by gneiss of Antigorio. The passage from one formation to the other is marked by a layer of gypsum mixed with decomposed gneiss. In the center, gneiss forms the principal mass, with beds of Teggiolo and Valle limestone breaking in on the south; on the north layers of crystalline schist join the compact mass of Monte Leone gneiss. The most recent formations are represented by the glossy schists and Rhone gypsum on the north. The direction of the strata is nearly perpendicular to the axis of the tunnel, or usually from N.E. to S.W., while the inclination varies from N.W. to S.E. The rocks to be traversed are suitable for boring by machinery. On the north the softness of the schist will allow of rapid progress, which, however, will be hindered to some extent by the necessity for timbering. In the central mass and the Antigorio gneiss it will be much harder; but the rock being compact for considerable lengths, there will not be much need for timber, so that there will be no difficulty in advancing at the stipulated rate of speed. In Brandt's rock drills, the pressure can be varied according to the nature of the rock.

The slowest progress will probably be made when passing through the layers of gypsum and dolomite. Still, they are of short length, and as the heading follows the floor line, it will be possible to open out the full section, and to timber rapidly. For this reason it is not probable that there will be a repetition of the

incidents which took place in the Gothard Tunnel in the part where the pressure was the strongest, under the plain of Andermatt. Water may be expected for the first mile and a half on the north side, and under the valley of the Ganter; also on the southern side, in the valley of the Cairasca between Pizzo, Valgrande and Teggiolo.

From about the fourth mile to the eleventh, that is for a distance of nearly seven miles, the temperature will exceed 87 degrees Fahrenheit, which is the maximum that has been registered in the Gothard Tunnel; and if we apply the rule established by observations in the Gothard, of an increase of 1 degree for every 80 feet in depth, it will attain a maximum of 104 degrees. The increase of temperature will be a little greater below depressions on the surface and a little less below the summits. At the points where excavation is being carried on, the temperature will be lowered by means of ventilation, and by sprays of cold water forced out under high pressure. Arrangements have been made for an air supply of 1,770 cubic feet per second, while that used at the Gothard Tunnel in 1878 was only 71 cubic feet per second.

(3) Exterior Stations.—On the north a new Brigue station 1,100 yards long will be built, about half a mile from the northern entrance of the tunnel. This will serve as a transit station, and will be provided with suitable buildings for the custom houses. It will have eight lines of rails. On the south it is arranged to have a station at Iselle, about 400 yards from the entrance of the tunnel. This is intended to be a crossing station, and will have four lines of rails.

(4) Hydraulic Power.—One of the most important points in arranging for the construction of a large tunnel is to ascertain the amount of hydraulic power which can be utilized. At Simplon the watercourses on the north side which may be taken into consideration are the Rhone, the Massa, the Kelchbach and the Saltine. These streams have been gauged, and the minima observed till the end of 1893 were: Rhone, above the Massa, 1,216 gallons per second; Saltine, at Brigue, 60 gallons ditto; Kelchbach, at Naters, 34 gallons ditto; Massa, near the road bridge, 61 gallons ditto. In order to obtain 1,000 horse power from the Massa or Saltine a fall of 1,600 feet would be required, while the Kelchbach would need 2,800 feet. As the machinery will be placed in a building 2,260 feet above the level, it would be necessary to construct a dam at the altitude of at least 3,860 feet or 5,060 feet. But at this altitude neither the Saltine nor the Kelchbach give more than half the quantity of water mentioned above, so that it would not be possible to make use of these torrents. Besides this, they are already used for saw mills, for which in winter they have hardly the necessary water. The Massa, it is true, could give sufficient water for 1,000 horse power, but it would require a watercourse at an altitude of 3,900 feet, exposed to the weather; and this would render the work liable to interruption during the bad season. If the water were conveyed in pipes able to stand the pressure, the expense would be enormous.

To be sure of an adequate supply, which can be increased if necessary, it will be necessary to have recourse to the Rhone. Between the mouth of the Massa and the bridge over the Rhone, near Vogelthurm, a distance of about four and a half miles, there is an average fall of 1·60 per cent. The most rapid fall in this stretch is in the neighborhood of Morel, where for 1,100 yards there is a fall of 2·70 per cent. It seems obvious that this important fall should be utilized, and that the dam should not, if it can possibly be managed, be placed at a greater altitude than 2,520 feet, so as to be able to take the water conduit round the village of Morel, without having to encounter serious obstacles. The water would be taken in the neighborhood of Gifrisch bridge, and would have to be conducted to Massaboden, on the left bank of the river, a distance of nearly 2¾ miles. Allowing a fall of three per mil, this gives an altitude of 2,478 feet for the top of the reservoir. If the depth of water in this be 7 feet, there remains an available fall of 200 feet. The line of pipes under pressure would have an internal diameter of 40 inches, and would be 875 yards long. With a flow of 6⅛ feet per second, this will give 330 gallons per second. Deducting 16 feet for friction, there will still be an effective fall of 184 feet. The launder leading to the reservoir will be 40 inches wide by 40 inches high, inside measurement. Running full this would give 465 gallons per second. It is estimated in the report that 330 gallons per second will give 840 horse power, and 465 gallons per second 1,180 horse power. If this latter should be found insufficient, it will be necessary to construct a second launder and a second line of pipes; so that when the first is put up, the supports will be made wide enough to allow of another being placed by its side. This would give 1,680 horse power under ordinary conditions, or 2,360 horse power when the launders were running full. In the latter case, the velocity in the pipe would be increased from 6⅛ feet to 8⅛ feet per second. There would then be taken from the Rhone 660 gallons per second for ordinary work, and a maximum of 930 gallons when both launders were running full. It would not be advisable to exceed this latter figure.

At the southern end of the tunnel are the Diveria, the torrent of Zwischenbergen, and the Cairasca. These streams have been gauged with the following minimum results:

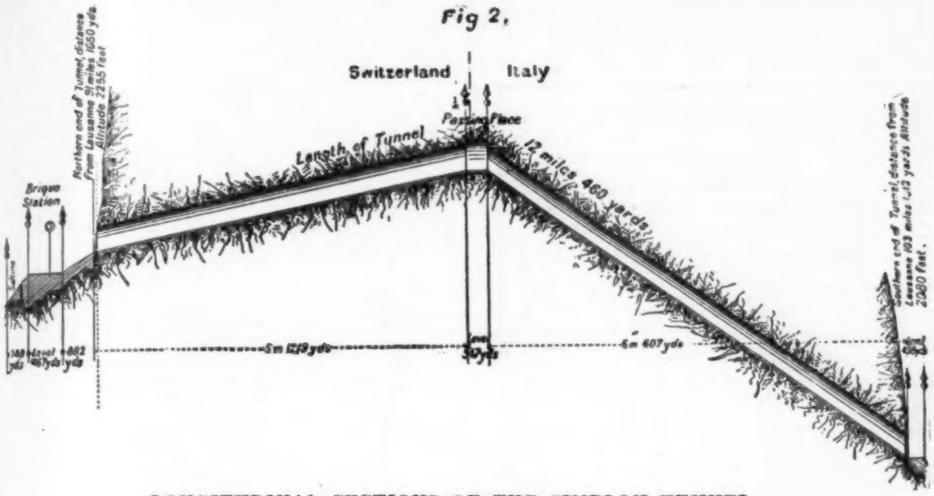
Diveria, above Gondo, 242 gallons per second; Diveria, below Gondo, 313 gallons per second; Zwischenbergenbach, 73 gallons per second; Cairasca, opposite San Bernardo, 147 gallons per second; Cairasca, below Maulone, 203 gallons per second.

As on the north, the smallest supply on this slope is in January or February, and the scarcity lasts about four months.

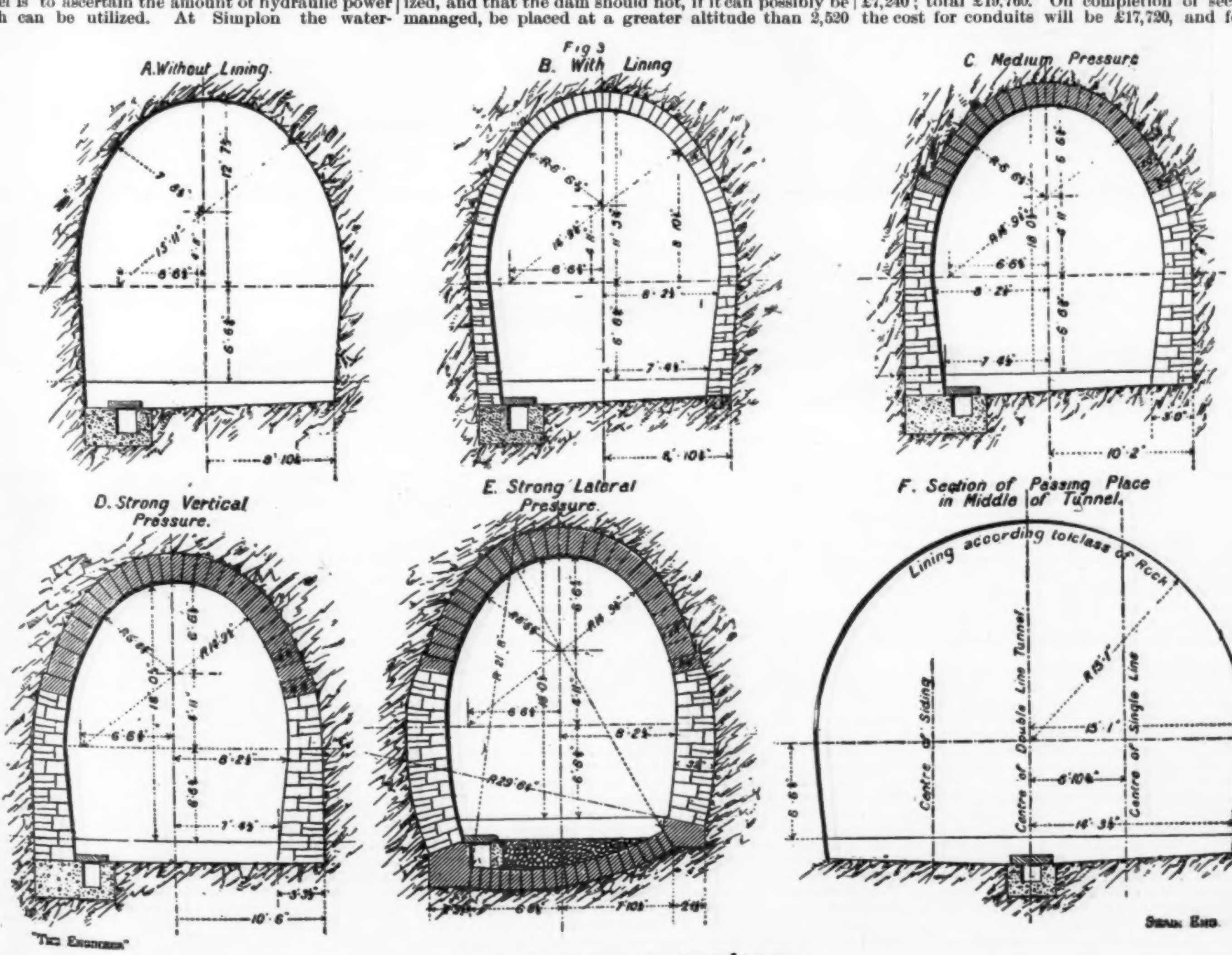
After giving reasons for not utilizing the Diveria or Zwischenbergenbach, the report states that on the right bank of the Cairasca the conduit would run through pasture lands; and that estimating that 1,630 horse power would be required, this could be obtained by taking 110 gallons per second, with an effective fall of 1,230 feet. The length of the conduit would be not quite three miles, and the internal dimensions 27½ inches by 27½ inches. The dam will be above the footbridge over the Cairasca, between Gebbo and Cisina di dentro. The conduit will be carried in a tunnel under the church of Trasquera, which will considerably shorten its length; but with that exception, it will be in the open air. The power house being at an elevation of 2,020 feet, the dam will be at 3,300, and the reservoir at 3,280. This allows for a three per mil fall in the conduit, and for an estimated loss by friction of 30 feet, for a pipe 24 inches internal diameter and half a mile long. The conduit, when running full, would take 154 gallons per second, at a velocity of 8⅛ feet per second, which would give 2,260 horse power.

The estimated cost for the water supply at the north end is, for first conduit, £12,520; first line of pipes, etc., £7,240; total £19,760. On completion of second line the cost for conduits will be £17,720, and for pipes

Fig 2.



LONGITUDINAL SECTIONS OF THE SIMPLON TUNNEL.



CROSS SECTIONS OF THE SIMPLON TUNNEL

etc., £14,480; total, £32,200. At the southern end the estimate is £13,440 for conduit, and £7,360 for pipe, etc.; total, £20,800. This gives £13 13s. per horse power at the northern end and £9 4s. at the southern.

(5) Contract.—The contract for carrying out the work was signed on September 20, 1893, with Messrs. Brandt, Brandau & Co., who have agreed to complete the construction for the following prices:

(1) Preliminary constructions	£280,000
(2) First single line tunnel with parallel gallery	1,900,000
(3) Completing the second single line tunnel	600,000
Total for two single line tunnels complete	£2,780,000

These prices do not include the purchase of land necessary for the different buildings, etc., the material for the permanent way of the two tunnels, or the ballasting of the second. The first tunnel is to be finished in five and a half years, if notice to commence the work be given between the 1st of February and 31st of July, and in five years and eight months, if the notice be given at any other time. The time for constructing the second tunnel is limited to four years from the time of commencing this part of the work. The contractors are to receive notice to begin it within four years from the date they finish the first.

As guarantee, a sum of £40,000 has already been deposited, and this will be increased to £200,000 by the retention of 7 per cent. on the amount of the monthly certificates. After the first tunnel has been completed and accepted, this guarantee is to be reduced to £80,000, and two years later to £40,000; finally to £20,000 at the end of three years. If it is decided to construct the second tunnel, this £20,000 will be increased to £60,000 by 7 per cent. retentions on the fresh amounts due. For two years after the completion of the second tunnel £20,000 will be kept as guarantee. A fine of £200 will be imposed for every day's delay after the date fixed for the termination of the work, unless this delay is caused by force majeure, for which the contractors are in no way to blame. On the other hand, they shall receive a bonus of £200 for every day that the completion is in advance of the stipulated time.

The contract will be canceled if the contractors dissolve partnership, or if they are at any time a year behind the agreed rate of progress; and in that case the retention money shall be forfeited to the company. The contractors can make no extra charge for unexpected difficulties—such as those caused by water, high temperature, or bad ground. They shall, however, not be liable, in case of war between Switzerland and Italy, epidemics, or a general strike, not arising from any fault of theirs. The contractors are to be allowed to choose which of the cross sections shown on Fig. 3 they consider suitable for each part of the work; but if there should be considerable pressure at any part, they undertake to make the masonry even stronger than that shown on any of the designs. The work is to be carried on day and night without interruption, Sundays as well as week days.

After sundry minor stipulations—such as the provision of free baths for workmen, insurance against accidents, etc.—the report gives a series of prices which have been agreed between the contractors and the company. This allows about £55 per yard run for the completion of the first 1,100 yards of the first tunnel, besides £14 per yard for the parallel gallery, with the drainage channel, and £11 5s. per yard for the connecting galleries. Prices for the tunnel heads, niches, signal chambers, etc., are also given. These prices are to be progressively increased, as the work advances toward the center of the tunnel. The following has been adopted as the normal rate of progress:

	Main and parallel galleries.	Upper headings.	Opening out to full size.	Masonry.
First year	1 mile 318 yds.	— 1,641 yds.	— 985 yds.	— 219 yds.
Second year	2 " 524 "	2 mls. 417 "	2 mls. 417 "	2 mls. 308 "
Third year	2 " 964 "	2 " 746 "	2 " 636 "	2 " 746 "
Fourth year	2 " 1,511 "	2 " 1,511 "	2 " 1,402 "	2 " 1,292 "
Fifth year	3 " 298 "	3 " 408 "	3 " 626 "	3 " 736 "
Last six months	— " 365 "	— 1,017 "	— 1,074 "	1 " 679 "

All the preliminary work is included in the first year, and all ballasting and plate laying in the last six months.

[FROM ENGINEERING.]

THE DRAINING OF THE ZUIDER ZEE.

A SCHEME which will take 33 years to carry out, will involve a total expenditure of £26,250,000, will lead to the reclaiming of 750 square miles of land from the sea for agricultural and other purposes, and will add a new province to the country which undertakes it, is one well deserving to rank among the greatest of practical projects that the science of engineering has yet advanced. Such, in effect, however, is the proposal put before the Dutch government by the Royal Commission appointed for the purpose of considering the best method of draining and utilizing a large portion of the area now flooded by the waters known as the Zuider Zee, though, at one time in history, forming part of the mainland itself. The problem has for many years engaged the attention of the engineers in Holland, the proposal being one that far surpasses in magnitude any of the other works of land reclamation previously carried out there; and the real question now at issue is not the practicability of the scheme, opinions on this point being almost unanimous, but whether the country will be justified in incurring the great financial obligations involved. Some members of the Royal Commission have, on this ground, hesitated to recommend the carrying out of the scheme; but the majority hold that, while the project may be regarded as one that would not be a good commercial speculation, still the government may at least hope to defray expenses by the sales of land, etc., while on the broader considerations of national progress—in the expansion of territory, in the increase of trade and agriculture, and in the giving to thousands of people the opportunities of profitable employment—the scheme, vast and costly though it be, is one that will certainly recommend itself to patriotic Hollanders, and insure for them, should they carry it out, the gratitude of future generations.

The work to be done, according to the proposals of the Zuider Zee Association and approved by the Royal Commission, is of a twofold nature: first, the construction of an extensive embankment from almost the extreme point of North Holland to the Friesland coast, so as to shut out the ocean from all further access to the Zuider Zee; and secondly, the formation, by means of further embankments, of four great "polders" on different parts of the shores of the Zuider Zee for the purposes of land reclamation. These are shown, not only on the map, Fig. 1, but in greater detail on the plan, Fig. 2. This is a very different, and, perhaps, not quite so striking a proposal as the original idea, first projected many years ago, of draining the whole of the Zuider Zee area and converting it into one vast basin of agricultural or pasture land. But it has one merit which the original proposals did not possess, and that is practicability. The greatest of the various problems which the engineers had to decide was what they should do with the rivers that now find an outlet into the Zuider Zee, and one cannot but feel that no more satisfactory solution of this problem could be found than the one suggested, which is not to attempt to drain the whole area in question, but to leave still a considerable expanse under water to serve the double purpose of providing an outlet for the rivers and of leaving open the waterways to Amsterdam, Kampen, Stavoren, and other places. The plans, too, are so arranged that these waterways will be precisely along the deep water channels, while the land reclamation will take place on what are the shallowest parts of the Zuider Zee. Instead, therefore, of the navigation to the principal ports being prejudicially affected, it will be greatly improved, because the possibility of vessels going out of their course and getting stranded on the sandbanks will no longer exist. This is a consideration to which much importance is attached, as it will practically abolish dangers of navigation which have led to the destruction of many a fine ship, and to the loss of many lives. There is hardly a sandbank in the Zuider Zee of which some more or less tragic story could not be told.

From an engineering point of view the most interesting part of the scheme is the construction of the great northern embankment which is to shut out the ocean, and change the region in question from a branch of the sea into an inland and, eventually, fresh water lake. After a good deal of consideration, in the course of which six different lines of direction were examined, the commission decided to recommend that this embankment should begin on the northwest coast opposite the island of Wieringen, and, in the first place, join that island to the mainland, thus closing the neck of sea known as the Amstel-diep. Commencing again on the western point of Wieringen, the embankment would stretch for close on 25 miles right across the Zuider Zee to the coast of Friesland, where it would join to the land again at Piaam. This embankment, as shown on the map, Fig. 1, is not only to shut out the sea, but is to form a public highway between North Holland and Friesland, and is to afford space,

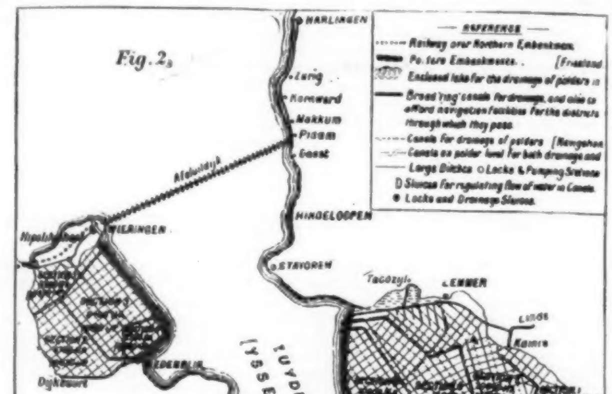
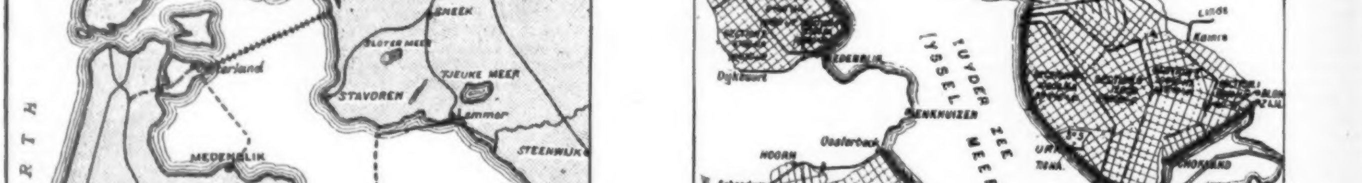


Fig 3



THE DRAINING OF THE ZUIDER ZEE.

too, for a railway connecting two portions of the Netherlands between which, save for a very wide detour, communication can now be carried on by water only. In order to fix the height of this embankment, the Royal Commission had first to consider what possible sea levels must be provided against, judging from past experience. The greatest height known to have been attained by the sea waves along the coast of the Zuider Zee was in December, 1883, when, during an extremely severe storm, the sea rose near the Noorderdijk of Drechterland, at Andijk, to a height of 2·30 meters above the sea level at Amsterdam, while the waves ran up to the summit of the embankment there, a height of 5 meters, and washed away the gravel road. The average height of the new inclosing embankment has, therefore, been fixed at 5·40 meters, that is to say, it will commence at 5·20 meters on the western side and rise gradually to 5·60 at the eastern. It is thus believed that the summit of the embankment will be safe even during the severest storms that are likely to occur. The island of Wieringen will be protected by an embankment of similar height.

The total width of the embankment above the sea level will be 70·80 meters, though the actual summit will have a width of only 2 meters, so that this portion of the embankment will not be available for vehicular traffic, for which provision is made at a lower level on the inner side. The general method of construction will be seen from the section, Fig. 3, for the right comprehension of which we may state that "N. A. P." is the abbreviated form of "Normal Amsterdamsch Peil," otherwise the normal sea level at Amsterdam. The embankment itself will be formed of sand and soil, with heavy stone facings on the lower portions on each side. The use of willow twigs will be an important feature in the making of the embankment, their merit consisting in the fact, so well recognized by Dutch engineers, that they solidify the layers of earth, etc., thrown upon them, and help largely to form an impervious mass.

The willow berme on the northern side will be protected by a mass of stone rubbish 1 meter in thickness, and just above it will be a stone "lip" inclosed between two rows of oaken piles. Then will come a talus protected by stone facing to a height of 4·50 meters above the sea level, the average thickness of the stone facing here being 0·40 meter, with a stipulation, however, that in the center it must not be less than 0·55 meter. The stone facing of the inner side—where it will rise to a height of 3·50 meters (increasing to 4 meters) above the sea level—is to be of equal thickness to that of the outer side, because, although this side will not be exposed like the other to the fury of the ocean itself, it will be steeper—3 in 1 as compared with 4 in 1—while the influence of wave action from the inland lake (otherwise the Yssel Meer, as it is to be called) must not be underestimated, more especially as such wave action may be of considerable force during the prevalence of gales from the south and southeast. Immediately above this inner talus there will be a stretch of level ground 17 meters in width, of which the outer 10 meters will be the track of a railway from North Holland to Friesland, and the remaining 7 meters on the inner side a carriage road. Then comes a space 3·50 meters in width and rising 2½ in 1, which will be used for the storage of material for repairing the embankment, and still higher will be the actual summit. Above low water there will be a layer of clay or loam 1 meter in thickness, except in regard to the railway track, where it will not be put at all, while in the case of the carriage road the thickness of the layer will depend on the material used for road making.

The one great idea of the engineers seems to have been to design an embankment which would be able to resist the strongest forces of nature ever likely to be brought to bear against it. On this point it may be of interest to quote the following observations from our Dutch contemporary De Ingenieur: "The commission have evidently tried to project a profile that, humanly speaking, affords absolute safety, and, in our opinion, they have succeeded in this. We are, however, not convinced that the same result might not have been attained in a somewhat more economical manner. The construction of the outer talus is, owing to the extent of the basalt stone facing, likely to be very costly. If the outer berme were constructed under an incline of 4 in 1 at a somewhat greater height than proposed by the Zuider Zee Association (0·50 meter, for instance), and if behind the incline a broad band of stone were placed, would not this afford an equally secure but less costly solution?

"Our second remark has reference to the carriage road by the side of the railway. Is it really to be expected that between North Holland and Friesland the ordinary traffic along the enormous distance of about 40 kilometers will be such as to warrant the construction of this roadway? We cannot suppose so, yet this consideration alone would justify so great an expenditure. The carriage of materials for maintenance, etc., would be better and in a less costly manner provided for by the construction of a simple narrow gauge tramway, while for the storage of such materials the summit of the embankment and the adjoining part of the inner berme afford ample accommodation."

The fact that there will be a constant inflow of water into the Yssel Meer from the various rivers now running into the Zuider Zee gives great importance to the question of constructing adequate sluices through which these surplus waters would escape into the sea, or, indeed, through which water could be admitted into the Yssel Meer for the purposes of military defense or otherwise. The final decision arrived at with regard to the position of these sluices, and also of the necessary locks, was that they should all be concentrated at one point on the easterly side of the island of Wieringen. Right through this island there is to be cut a canal 1,000 meters in breadth, increasing at the northern end to a breadth of 1,200 meters between the two pier heads, of which that on the west will extend 1,300 meters and that on the east 750 meters beyond the Wieringen embankments. The depth of the canal will be 5 meters below low water. On the southern side the canal will widen to 1,500 meters at the junction with the Yssel Meer. The walls, constructed of basalt, will reach a height of 1·50 meters above the sea level. Across this canal, and occupying altogether 775 meters of its total breadth, will be five groups of six sluices each, with plateaux 100 meters broad between the groups. These sluices are to have a depth of 4·40 meters below the sea level, and are to be limited in width to 10 meters each, so as not to afford facilities for the entrance of hostile ships into the Zuider Zee in case of war. In this large canal a dam will be constructed in order to form on the west and alongside of the sluices a navigable canal 150 meters wide (increasing on the north to 250 meters); and here there will be two locks lying side by side, one of them 10 meters wide and 97·50 meters long, and the other, intended for fishing boats only, 6 meters wide and 40 meters long. The sluices, it may be added, will be so arranged as to allow of the height of the water in the Zuider Zee being strictly regulated, while the effect of their working, combined with the steady inflow of water from the different rivers, will be such that the waters of the Zuider Zee will be entirely changed from salt into fresh within three years of the time when the closing embankment is completed.

Operations are to be commenced by the filling in of the Amstel-diep and the construction of an artificial island on what is known as the Breesand, situate half way between Wieringen and Friesland. Each side of this island would have a harbor of 1,500 meters in length and 100 meters broad as a basis of operations, so that work on the main embankment could be carried on independently from four different points at once, namely, the two harbors, the eastern point of Wieringen and the coast of Friesland. But even in this way it is expected that the work of constructing the embankment alone would extend over a period of nine years.

The second division of the scheme deals more especially with the land reclaiming, which will not be taken in hand until the great northern embankment has been finished, and operations can be conducted without the difficulties that would arise from tidal changes in the water level. The "polders," as already stated, will be four in number (Fig. 2), and the course pursued by the Dutch engineers may be briefly described as follows: Along the outer line of the space to be reclaimed, in each instance, a dike will be constructed powerful enough to keep out the force of water represented by the Yssel Meer, such dike being much about the same in form and character as the northern embankment, though, of course, it will not require to be so strong as the one that is to keep the ocean itself in check. Each dike will be broad enough to have its roadway and pumping stations, and as soon as it is ready these stations will be built and the pumping engines will be set to work to pump the water out of the inclosed space into the Yssel Meer. As already mentioned, a great deal of the Zuider Zee consists of shallow sandbanks, and it will not take long, when the pumps are in full working order, before these banks appear above the surface of the water. As soon as a certain space is cleared it will be surrounded by a small embankment and form the first section, on which operations with a view to preparing it for agricultural purposes may be commenced at once, while the pumps are operating on the lower parts of the large inclosed space that are still under water. So the work will go on until the whole of the space inclosed by the main dam of the polder has been laid dry, and the different sections of that polder, each with a separate embankment of its own, and varying in shape according to depth, have been completed. The polders will, of course, be fully protected from any inflow of water from the Yssel Meer, while the drainage of an expanse of land which will lie considerably deeper than the surface of the lake shut out from it will be secured by a network of canals of various dimensions and at different levels, the water being pumped from the lower into the upper until it can run into the Yssel Meer, and thence through the sluices into the sea. All this, however, will be a familiar story to those who are familiar with the construction of the polders already existing in various parts of Holland. But, although the work itself may be much about the same, never before has it been projected on such a scale as this, for the total extent of the area to be reclaimed is no less than 750 square miles.

The four polders will be dealt with in the following order: (1) northwest; (2) southeast; (3) southwest; (4) northeast; and the plan of operations is so arranged that the whole work, including the construction of the northern embankment, will extend over 33 years. The total cost, including compensation in respect to the destruction of the Zuider Zee fisheries, is put down at £26,250,000. On the other hand, something like 25,000 acres of reclaimed land will be made ready each year, and the capitalized value of the land to be recovered for the purposes of Dutch agriculture is estimated at £27,166,000. But the commission urge in their report that beyond the mere question of pounds, shillings and pence, there are many substantial though indirect advantages which Holland would secure from the carrying out of this great scheme.

The engineer who is chiefly responsible for the scheme in the form it has finally assumed is Mr. C. Lely, who was himself chairman of the Royal Commission, and was also for a time minister of the water department of the Dutch government. Mr. Lely has devoted great attention to the project, more especially since 1886, when the Zuider Zee Association came into existence. He it was who brought forward the proposal for the great northern sea wall, with its locks and sluices, and first offered something really practical for consideration, in place of a variety of other proposals which were all more or less impracticable. Whether or not the Dutch government will be able to summon up sufficient courage to give the order for the execution of this most ambitious and most costly scheme is a point that the future must decide.

SHIP'S COURSE RECORDER.

WE have had the opportunity of examining a very ingenious instrument, invented by the late Mr. Arthur Wrigley and Mr. John Hope, for recording the course of a ship as it proceeds on its journey. Although the invention has been before the public experimentally for more than three years, the whole of this time has been spent, we understand, in observing its behavior, in adding improvements, and in reconstructing the instrument, so that the instrument as now made is put forward as being the best result up to date that has been produced, by which the difficulties at first experienced with the initial machines have been overcome. We illustrate this machine and the record produced by it, in the adjoining diagrams, in which Fig. 1 is a perspective view of the complete machine and Figs. 2, 3, and 4 represent records from the machine.

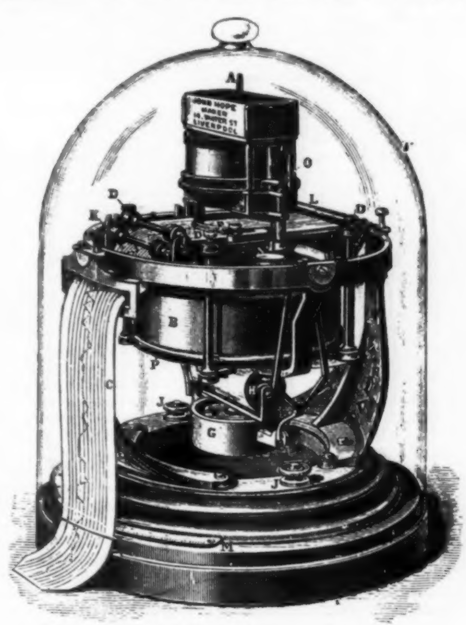


FIG. 1.

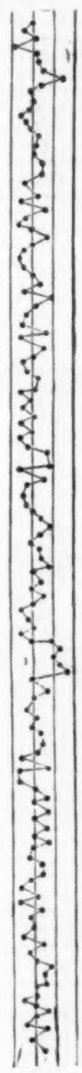


FIG. 3.

FIG. 2.

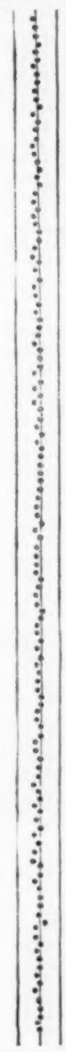


FIG. 4.

Broadly speaking, the machine consists of a timing mechanism or clock, which is adapted to produce the travel of a paper ribbon at a uniform speed, and a marking device for producing the record on the paper ribbon, the movement or position of the marking instrument being controlled by a system of permanent magnets. By reference to the illustration, Fig. 1, it will be seen that the clockwork, A, is mounted at the top of the instrument, and is carried by the main framework, which is arranged to swivel upon the baseboard, upon which a divided arc, M, is fixed to indicate the angle of the chart with the keel of the ship, clamping screws, J, being provided to fix the instrument in position when set. The chart, C, is carried on a spool or bobbin, H, and is led upward on one side of the instrument and across the top, and, passing under the pressure rollers, K and L, is led down the other side.

Beneath the chart is a bowl, B, carried upon a platform, P, which contains the magnets and the liquid in which they are immersed. Upon the axis of the magnets projects, on its upward end, a double arm, which carries a perforating pin at each end of the

arm, one pin for a northward course and the other for a southward course. Upon the upper side of the chart a protractor, F, is mounted on the frame, so as to rest upon the chart and form a resistance against which the perforating pins act when they perforate the chart. The protractor is in a circular form, and lies just over the path of the perforating pin. At the bottom of the instrument is an anti-oscillator, which is filled with glycerine. A handle, O, is provided for stopping and starting the clockwork.

Now the purpose for which the instrument is intended is to record the course of the ship at sea; in other words, to show how she has been steered, or has behaved, under different conditions of weather.

Owing to the way in which the magnets are mounted, they are not affected to the same extent as the ordinary compass card by the rolling of the ship. The ribbon of paper, which is 3 in. wide, and moves at the rate of 3 in. in the hour, is ruled with parallel lines projected from points 5° apart on a semicircle. Now, for the sake of clearness, we will assume that the machine is fixed so that the chart is traveling in a line parallel and coincident with the keel of the ship, and that the ship is traveling due north. Now, bearing in mind that the perforating pin under the chart is controlled by the magnets, as long as the ship moves in a straight line due north the perforations on the chart would be made on the center line of the chart; also, that should the ship deviate from the course, the perforating pin will move from off the center line and perforate the chart off the center line. For example: if the ship deviated 5° from her course, the perforations would be made on the first 5° line on one side of the center line. The clockwork operates the perforator once every minute, so that a continuous record of the course of the ship is produced, the perforations being made in equal intervals of time. By reference to Fig. 2 transverse oblong perforations indicate a southward course and round perforations a northward course.

It will be obvious from the above description that when the ship is on any course, and the instrument is adjusted so that the chart travels north and south, the course line will be produced in the way described. It will be understood, of course, that the direction of the ship may be altered within 90° without setting the instrument afresh, and an intelligible chart from it obtained; but at the same time, it follows that the most correct chart is obtained when the course line is produced on or near the center line. This may be secured by swiveling the instrument over the arc, M, as mentioned above, a number of degrees equal to the altered bearing of the ship.

The chart shown in Fig. 3 is taken from a big Atlantic liner the first time the recorder was in use on board; while Fig. 4 represents a chart made some two or three months later, and shows a marked improvement of the steering compared with the former.

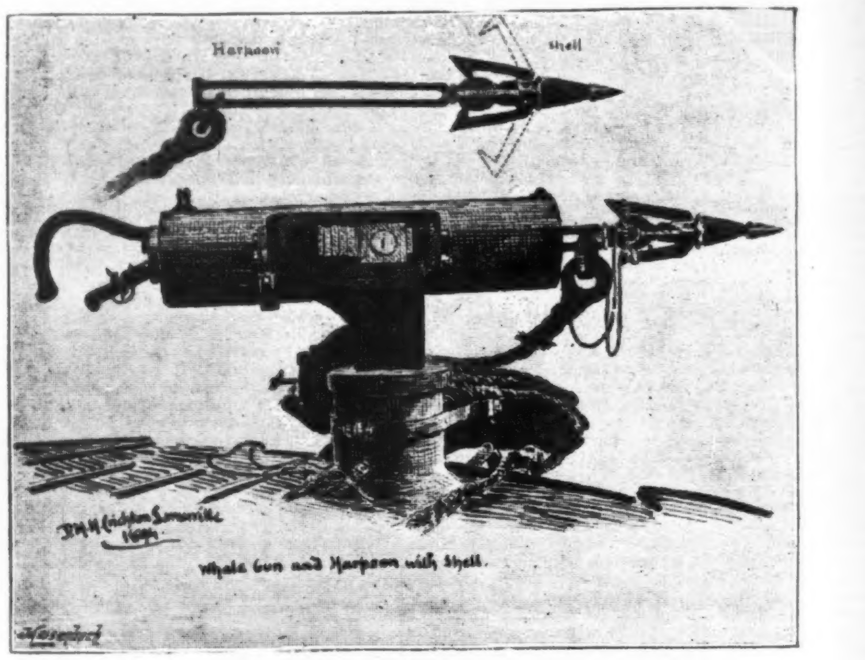
If it were possible to steer a perfectly straight course, the record would be a perfectly straight line. The difference in skill between a bad steersman and a good one is thus graphically illustrated, which certainly should tend to promote a spirit of emulation among the men selected for that duty.

Better steering must, in more ways than one, tend to economy. Bad steering must not only lengthen the passage, but, by frequently causing the rudder to make a large angle with the keel, retard the ship; on the contrary, good steering will shorten the passage, reduce the expense, and, in a steamship, will make itself felt directly on the coal account, and indirectly in all other expenses of the ship. In this instrument the captain will have a valuable check upon the officers whom he leaves in charge while he himself turns in to rest, as when he returns he may at once see what movements the ship has made in the interval, and if his orders have been obeyed or otherwise. This being known and understood, will secure for him the greatest amount of care and watchfulness on the part of the subordinate officers, independently of whom he will know all that has taken place before he leaves his room. Without this instrument he might go on deck to find the ship on her course, and learn no more; but with it he would learn if she had deviated at all, how often, and how much. Every movement of the ship's head, whether made to obey a signal, avoid a danger, or caused by bad steering, would be duly recorded. He would thus be prepared, if the occasion required, to take the initiative by asking for explanations. This is an advantage that will be appreciated, for it has never before been done.

In sailing ships, equally with steamships, this instrument will have its uses. When the ship is close-hauled, tacking first on one side of her course, then on the other, the angles she makes and the time occupied on each tack will be recorded. In foggy or murky weather, when astronomical observations cannot be made, the diagram will be useful in showing how much the ship "knocked about," in ascertaining the position, computing the progress, and will be most valuable in the event of a collision.—The Marine Engineer.

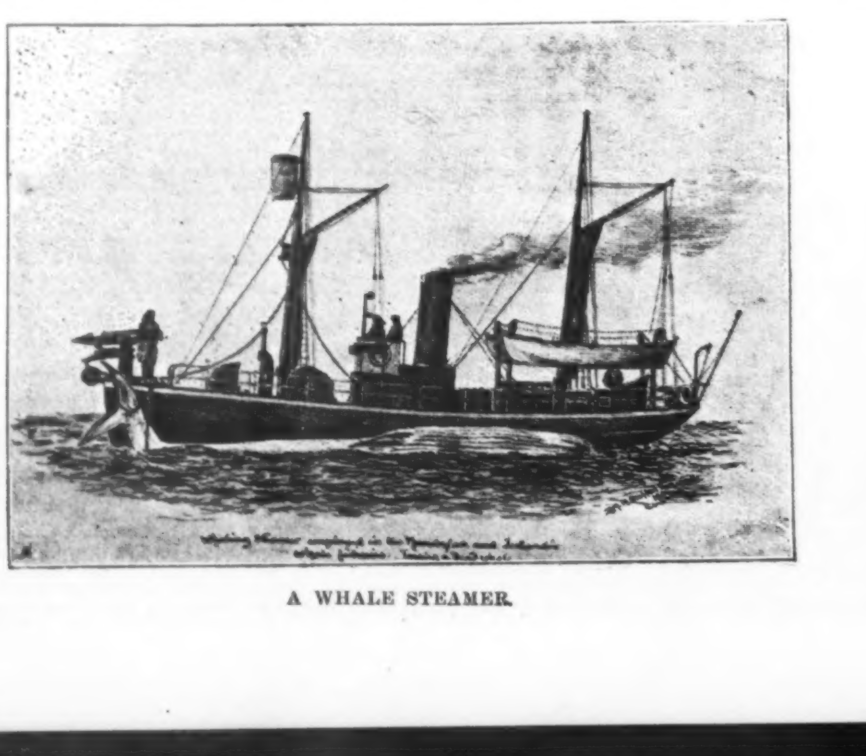
STEAM WHALING.

SVEND FOYN, born at Tonsberg, Norway, July 9, 1809, rose from being a cabin boy, at eleven years of age, to being the greatest enemy to the whale tribe that has ever lived, and one of the greatest benefactors to his country. He led a poor life until 1845, when he had saved enough to purchase a brig, which, after a few years, enabled him to make a fine take of seals off Jan Mayen. This brought him in over £4,000, and from that moment he prospered in everything he undertook. In 1863 he turned his attention to the whale fisheries of Finmarken, and commenced the chase with a small steamer, the Spes et Fides, but the result was disappointing. He saw that the hand harpoon was but a primitive implement, and set to work to construct one to be fired from a gun. He succeeded in producing one, which he improved in time and supplied with a shell which, bursting when in the vitals of the whale, either killed it at once or wounded it so as to reduce its escape to a minimum. The invention cost him nearly £9,000, but be patented it in all lands for ten years, and shot the leviathans "like one shoots birds," to use his own words, making an immense fortune, which he has made good use of in establishing schools for practical education, supporting charitable institutions, missionary associations, etc. The small steamers which he originated, armed with his formidable guns and shell harpoons, are now employed in great numbers off the Norwegian coasts and in Icelandic waters, and give employment to thousands of hands, both in the chase and in the immense factories in which every portion of the whale is now prepared for some branch of industry.



WHALE GUN AND HARPOON.

The chase of the whale is an exciting pursuit, occasionally a dangerous one, for this year a wounded whale charged a steamer and injured her to such an extent that she had to be beached, while another whale, in which the shell had not exploded, was hauled in a dying condition alongside. The missile, then bursting, blew a hole in the vessel, and she foundered in deep water. The gun is fired when the whale is from twenty to thirty yards distant. The harpoon penetrates the blubber and enters the vitals of the animal, and as soon as the strain comes on the hawser the flanges of the harpoon open out, and in doing so break a glass tube of acid which, combining with another chemical, fires the shell. It happens occasionally that the wounded whale will tow the vessel at a rate of up to thirty knots, and sometimes at a good pace for many hours, before becoming exhausted. Foyn himself was thus once towed in his steamer for ten hours in the teeth of a gale, when the hawser finally parted and the whale escaped. In 1870 Svend Foyn was made knight commander of the Order of St. Olaf for meritorious services, and subsequently knight of the Grand Cross of that order. He died suddenly of paralysis of the heart.—The Daily Graphic.



A WHALE STEAMER.

LUBRICATING GREASES.

THESE greases are made of a great variety of materials, good, bad, and indifferent, for some anything is thought to be good enough while there are others which are made of good materials for lubricating certain special bearings where no other kind of lubricant can possibly be used.

To these greases fancy names are often given, more or less descriptive of the particular purpose for which the grease is to be employed, while some of the names are altogether fancy and are not indicative either of the use or the composition of the grease.

Most lubricating greases are made by treating a grease oil or fat with an alkaline body, when a soap is made, which, amalgamating with the rest of the oil, makes the latter stiff and greasy. The two alkalies chiefly used are lime and soda, the former when crude, rough greases are required, the latter when better qualities are desired, although some greases do not contain any alkali at all. Sometimes, what are known as fillings are put in; these consist of such bodies as powdered gypsum, mica, French chalk, black lead, etc.; some of which add to the lubricating value of the grease, while others do not, and are put in to make the grease apparently stiffer.

The following oils and fats are used in making these lubricants:

Palm Oil.—This material is used in making the best qualities of loco greases. For this purpose the poorer qualities of palm oil, which are rich in free acid, give rather better results than the best qualities, because during the process of making the acid enters into combination with the alkali used and forms a soap which amalgamates with the remainder of the oil and any other oil substance added to form the grease. If the palm oil contains little free acid, it is obvious that this saponifying action cannot take place, and the formation of grease takes place imperfectly.

Tallow is frequently put into greases. Of course only the commoner qualities are used, as the finer grades have greater value as soap stock.

Oil foots of all kinds are commonly used They are scarcely usable for any other purpose, owing to the coloring matter and other impurities they contain.

Resin Oil is one of the commonest grease materials, and generally the crude grades are thus employed. Two or three such grades are made and distinguished as "soft," "medium" and "hard," the latter being that chiefly used in lubricant making. Crude resin oil is a thick materiai containing some portion of solid matter. It is acid in character, the degree of acidity being greatest in the "hard" resin oils and the least in the "soft." Besides this acid, the oil contains some hydrocarbon oils, and oils which are more or less acted on by alkalies. Resin oil is used chiefly in combination with slaked lime, using about three times as much oil as lime. When well mixed the mass is placed on one side for a few hours. During this period most of the water with which the lime was slaked exudes. If a better quality of grease is required, a mixture of resin oil and palm oil is used. Resin greases possess the feature of being rather repellant to water, and therefore they are suitable for gearing which is exposed to the weather.

Anthracene Oil is a by-product obtained from coal tar; it is a dark greenish brown liquid oil, the color, however, varying considerably. It is rather heavier than water, the specific gravity being 1·065 to 1·100. It

smells strongly of tar oils. Mixed with lime, it forms a thick but oily grease. It is a cheap material, probably the cheapest of all the grease stocks, and is therefore much used in making the cheaper qualities of greases.

Yorkshire Grease or brown grease is often added in larger or smaller proportion to these lubricants. It is a stiffish grease of very variable composition, and is made by treating the soap liquors obtained in the scouring of raw wool. It is very acid in character, and is consequently easily transformed into a soap by means of lime or soda, and forms a very stiff grease which does not melt easily. The peculiarity of brown grease is that it contains a body known as cholesterine, the true wool fat, which has a high melting point. It has the property of taking up a large proportion of water.

Dark petroleum oils are often mixed with greases to give them greater lubricating powers. These oils are of brownish color, varying in consistency from liquid oils (summer dark) to thick, tarry oils (cylinder oils). They are perfectly neutral, and have no power of combining with alkalies; they will dissolve soap when the latter is presented to them in a dry condition. These oils are fairly cheap. In some of the better qualities of greases the filtered petroleum oils, which are of a pale brown or yellow color, are employed.

Regarding the use of caustic soda and lime, little need be said. The former gives smoother greases than the latter, and its soaps are more easily soluble in the other oils. Lime is the cheaper of the two, and is hence used in making the cheapest greases; it gives stiffer greases than soda, which have a higher melting point.

Of the filling materials used, gypsum, or mineral white, has no lubricating power at all. French chalk possesses some slight lubricating properties, being smooth and soft to the touch. Black lead, or plumbago, is a well-known lubricant, especially for wood.

MANUFACTURING RECIPES.

The following details, showing the method of making various kinds of lubricating greases, will be found of service:

Wheel Grease.—Take 5 lb. of quicklime and slake it with 20 lb. of water; then sieve well, and stir into the lime paste four gallons of "soft" crude resin oil; then allow it to stand for 12 hours. Pour off the water, and stir in five gallons of anthracene grease oils. Now heat the mass to 240° F., stirring well the whole time, until a good mixture is obtained.

Tram Grease.—Take 10 gallons of anthracene oil and stir in a paste made from 5 lb. of quicklime, well slaked, and mixed with 5 lb. of ground gypsum; then heat up as before. In heating greases containing water care must be taken, as they froth a good deal, and hence a capacious vessel must be used. Too prolonged heating is to be avoided, as with some greases so doing reduces the stiffness very considerably.

Hot Neck Grease.—Take 20 lb. of a good soap, cut in thin flakes, and dry it. Then take 30 lb. filtered cylinder oil, and 30 lb. 0·915 petroleum oil. Mix the two together, and heat to 240° F. Then add the soap, and stir well, maintaining the heat until the soap and oil have amalgamated, when the mixture may be allowed to cool down. When cold it will be found to be stiff.

Axle Grease for Wood.—Take two gallons of resin oil, and stir in 5 lb. of quicklime, slaked with two gallons of water, then stand for 12 hours, or until the next day. Pour off any water which may separate, then stir in five gallons of coal tar grease oil and 5 lb. powdered black lead. Generally it will be found sufficient to mix the materials cold, but a little heating will make a more homogeneous grease.

Loco Grease.—A common kind of loco grease can be made from 60 lb. Yorkshire grease mixed with 20 lb. of summer dark oil, and heated with 6 lb. quicklime, slaked with two gallons of water. The best loco grease is made from palm oil, tallow, seal oil, and soda crystals. The soda crystals are dissolved in about an equal weight of water, and then stirred into a melted mixture of the fats. The proportions used are varied according to the season of the year. In summer a stiffer grease can be used than in winter. This variation is attained by using more palm oil and soda crystals in summer than in winter, while it is also the custom to add a little more sperm or seal oil in winter. The proportions can be varied to some extent. Too much soda should be avoided, as any excess tends to make the grease hard.—Chem. Tr. Jour.

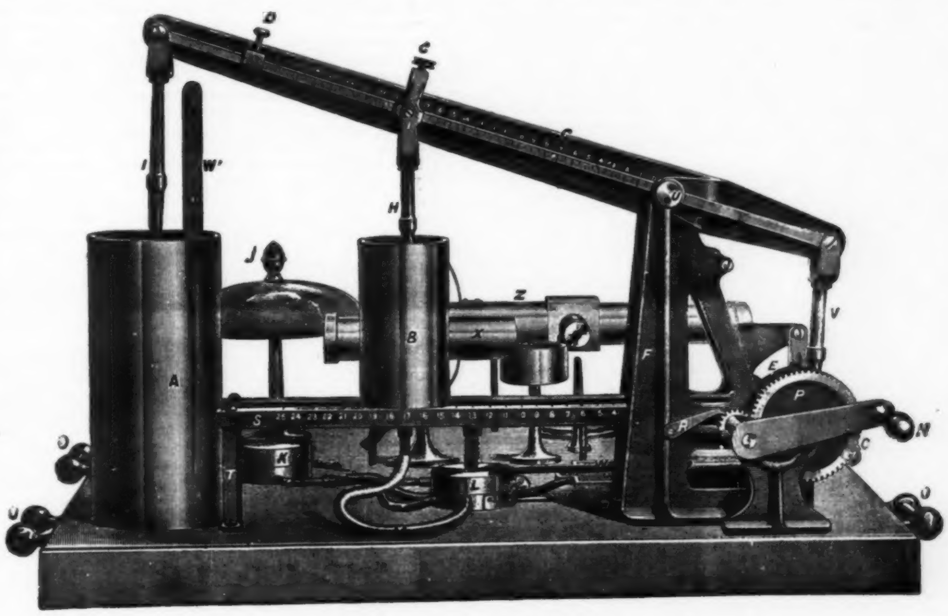
THE SHAW GAS TESTER.

By JOSEPH R. WILSON, Philadelphia.

THE apparatus is made of brass and iron, is about 2 feet square, and weighs 90 lb. It consists of a pair of pumps, A and B; one, A, takes in air, the other, B, takes in pure gas as a base to measure from. The air cylinder is stationary, and the stroke of the piston is always constant. The gas cylinder, B, is movable, and can be set between two graduated bars so that it will pump 1, 2, 3, 5, or any desired percentage of gas in conjunction with air from the air cylinder, the sum of the two always equaling 100 parts, so that if 2 per cent. of gas is taken in the gas cylinder, 98 per cent. of air would be taken in the air cylinder; and if 20 per cent. of gas, there would be 80 per cent. of air, and so on, the calculation on the graduated beam on which the gas cylinder operates having been made in a curve, so that the sum of the two cylinders shall always equal 100 parts; instead of 100 of air and 2 of gas, or 100 of air and 10 of gas, the product is 98 per cent. of air and 2 of gas, and 90 of air and 10 of gas. The pistons are operated by a hand crank, N, acting on the graduated arm or lever that regulates the stroke of the piston in the gas cylinder, and the product of the two cylinders is pumped through an ejector or mixer (not shown) into an igniting chamber, Z, which has an aperture on one side in front of a gas jet. Should the mixture pumped into the chamber be inflammable, ignition will take place, and the expansion caused by the heat will propel a loose piston head, held in place by a bowstring, at the end of the chamber against a gong, producing an audible sound. The addition or subtraction of 0·1 per cent. will cause this gong to ring or remain silent; in other words, this apparatus will determine the igniting line of gases which lies within the narrow limits of the 0·001 part, and which is as fine as the line between oil and water in a test tube. The test for inflammable gas is made on this basis, the igniting line. Philadelphia illuminating gas rings the gong at 8·1 per cent. of gas and 91·9 of air, though this will vary in manufacture; 8 per cent. of this gas will not ring the gong, the addition of 0·1 per cent. being necessary. This is what is called finding the standard, or base line to measure from, which varies with the kind of gas used. Natural gas will give a standard from 4 to 6 per cent., while manufactured gas may be anywhere from 7 to 8 per cent. This difference does not alter the condition of test, as the igniting line can be ascertained, whether it be at 4 or 9 per cent.

The air in the mines to be tested is captured by means of a diaphragm hand pump and a 6 gallon rubber bag. The diaphragm pump is light and easily handled. The vibration of the diaphragm throws about 1 pint of air each stroke. The air is drawn in a tube ⅜ inch in diameter, and forced into the bag. When filled the bag is held by the hand, in close contact with the neck, and pulled off the pump, and an ordinary paraffined cork inserted to retain the captured air. When the bags are filled, small paper tags are attached to note the time of day and place where the air was captured, and the bags brought either outside or to the foot of the intake, where they are attached to the instrument, and the contents made known as follows:

To test for fire damp, a bag of pure carbureted hydrogen, captured from a blower in the mine, is used as a standard, or in its absence ordinary illuminating gas may be used. For instance, 6 per cent. of the gas will ignite, 5·9 per cent. will not, 6 per cent. is then the standard line to measure from. The process of testing a bag of gas captured in the mine is very simple. Attach it to the air cylinder of the instrument, then pump a stroke of the air from the mine, and 6 per cent. of carbureted hydrogen into the igniting chamber. If there be any fire damp in the air from the mine, it will manifest itself at once by producing a louder detonation than that caused by the 6 per cent. of fire damp alone, or if there is a high percentage in the bag, there will not be any detonation, simply a long blue flame.



THE SHAW GAS TESTER.

It is known that there must be 6 per cent. of pure marsh gas to ring the gong by a previous determination; so if the gas cylinder be retreated and only 4 per cent. of fire damp be taken and the gong still rings, the extra 2 per cent. to make the gong ring must be obtained from the bag of air captured in the mine. So keep retreating the gas cylinder until the gong will just cease to ring; the difference between the standard 6 per cent. and the point where the gas cylinder stands at on the graduated beam will be the contents of the bag being tested, or if the gas cylinder is at 1 per cent., it would be evident that 1 from 6 would leave 5, and that 5 per cent. would be the contents of the bag being tested. If the gas cylinder is at 5·8 when the gong ceases to ring, 0·2 per cent. would be the contents of the bag. A 6 gallon rubber bag of fire damp or illuminating gas, whichever is used, will last a week, testing every day.

The valuable features of a test of this character are absolute accuracy; ability to test low percentages or any percentage; and safety in making tests, for the air can be captured in the dark by means of the diaphragm hand pump and tested in the open air far removed from the seat of danger. Air can be captured in the goaf and disused workings, and the condition of the goaf and disused workings unmasked without any danger to the miners. With the Shaw gas tester the manager of a coal mine is able to determine at once the condition of the gases, inflammable and non-inflammable, in every air return, to the 0·001 part, and with the knowledge of the true condition of the gases in every section of his mine, forewarned of any danger, he will be able to take proper precautions for safety. Heretofore the mine manager in the States has had to rely on the safety lamp for the detection of inflammable gas in the different air currents, and unless there was 2¼ per cent. present, he would report "no gas," because the lamp failed to indicate the presence of gas if below this percentage. This is where all the danger lies. Supposing an air return of 100,000 cubic feet per minute were to carry 2 per cent. of inflammable gas, the ordinary safety lamp would not give any evidence whatever of the presence of the gas, and the men would work in a false security based on the lamp test, whereas actually there would be 2,000 cubic feet of gas per minute passing a given point, or enough to saturate 20,000 feet of air to the explosive point.

So long as the ventilation was kept up, and none of the doors were left open, everything would be all right, and it would be impossible to ignite 2 per cent. of fire damp; but on the other hand, if anything happened to the fan, or a door was accidentally left open, the 2 per cent. of gas traveling in the air course would form in ten minutes 200,000 cubic feet of explosive compound. The man at the face feels the air grow hot and sultry, and realizes that the ventilation has been stopped or cut off and comes down with his light (frequently a naked light) to ascertain the reason. Ignorant of the true conditions, falsely imagining that there is no gas present, he walks into the explosive mixture with his light, an explosion follows, and he, and perhaps a score of his comrades, are hurled to their death.

The detection not only of its presence, but of 0·1 per cent. of gas, is not only a great achievement, but an absolute triumph over the old method of analysis, and may be termed the first mechanical analysis of gas ever made in the world. The writer could recount many tests, but having shown the great accuracy of the instrument for testing for inflammable gases, he will now go on a little further and show that its uses do not end with the testing of inflammable gases.

The instrument can be used for testing the sensitiveness of every kind of safety lamp for coal mines, and the manner in which it is done is as follows: Attach a large bell jar to the instrument by means of a rubber tube, immerse the bell jar in a tank of water and displace the air in it, and place the gas cylinder at five per cent., pump a mixture of 5 per cent. of inflammable gas and 95 per cent. of air into the bell jar, displacing the water in the same by the inflowing current, place a lighted safety lamp under the bell jar and immerse it in atmospheres containing 5 per cent. of inflammable gas, 6 per cent., 7 per cent., 8 per cent., or any percentage desired, which can be pumped upon the lamp, and the action of the flame witnessed through the glass. The elongation of the flame is not so noticeable in daylight as it would be in darkness, which latter is absolutely necessary for the accurate testing of the sensitiveness of safety lamps by this method.

The next test is that for carbonic acid gas, and in order to illustrate this test, let us presume that the writer has exhaled his breath into one of the rubber bags. Now the question is, How much carbonic gas does it contain? In order to ascertain this, the gas cylinder is placed at zero and the bag containing the author's exhalations is attached to the air cylinder only; by means of the instrument, the author passes the exhalations through a test tube containing an ounce of lime water until he produces a certain turbidity equal to an artificial standard of a known value. For instance, the artificial standard which the author uses represents 0·50 of a cylinder of 1 per cent. of carbonic acid gas and 99 per cent. of air. What volume of the exhalations will give the same result is determined by connecting a spray tube with the instrument by means of a rubber tube, and passing the exhalations from the bag through an ounce test tube of lime water, allowing the bubbles to pass up from the bottom of the test tube and permeate in little globules through the water until the same turbidity as the standard is produced. The graduated strip on the side of air cylinder shows that it has just taken 0·18 of a cylinder of exhalation to produce the same turbidity as 0·50 of a cylinder of 1 per cent. of carbonic acid gas and 99 of air. What does this indicate? Divide the 0·18 into 0·50 and we have 2·78 per cent. of carbonic acid gas in the exhalations just tested.

The last important feature of this instrument is its ability to demonstrate the effect of noxious gases upon animal life. The animal under treatment is placed in a bell-shaped glass cylinder 16 inches high, 4 inches diameter at the neck, and 8 inches at the base. The cylinder is placed horizontally on the table, with the neck toward the operator, and is connected with the instrument at the neck by means of a rubber tube. The animal rests on all fours, facing the operator, with its nose near the aperture through which the gases enter to the cylinder from the instrument or mixer.

The end of the bell-shaped glass cylinder is entirely open to the air, so that the mixture of gas and air is discharged and replaced every four seconds by each stroke of the pump, always maintaining a con-

stant mixture, preventing stratification or contamination through the exhalations of the subject. The cylinder being of glass and perfectly transparent, enables the operator to observe every change in the condition of the animal.

The author found in recent experiments that he made in his laboratory that, notwithstanding the deadly claims made for carbonic acid gas, a rabbit existed with very little evidence of dissolution in an atmosphere of 25 per cent. of carbonic acid gas and 75 per cent. of air. This one fact alone is of great importance to the miner in case of an explosion followed by after-damp, for though 50 per cent. of carbonic acid gas will overcome him very quickly, he could at least stand 25 per cent. for several minutes, or probably long enough to drag out a dying comrade, that is, in the absence of white damp or carbonic oxide gas.

ACETYLENE.

THE COMMERCIAL SYNTHESIS OF ILLUMINATING HYDROCARBONS.*

By Prof. VIVIAN B. LEWES.

THE two methods most used in chemical science for tracing the changes taking place in matter and determining the composition of bodies are, first, the breaking up of compounds into their ultimate constituents, a process which is called "analysis;" and, secondly, the building up of the compound from the elementary matter which forms it, a process to which the name of "synthesis" has been given.

If we take chalk and heat it in the limekiln, or in the chemist's crucible, a heavy, colorless gas, called carbon dioxide, escapes from it, and leaves behind a substance which we know as quicklime. If, now, this quicklime be further acted upon by chemical methods, it can be shown to contain the metal calcium and the elementary gas oxygen, while the carbon dioxide when collected can be decomposed into the elements carbon and oxygen, and by such a series of operations as this we might perform the analysis of chalk.

If now we start with the metal calcium, with carbon, and with oxygen, it is perfectly simple to reverse the operation, and rebuild the chalk molecules from these elementary forms of matter; by burning the carbon and calcium respectively in oxygen, we obtain the quicklime and the carbon dioxide, and by bringing these substances together in the presence of moisture, chalk or calcic carbonate is once more formed, and we have synthetically built up the chalk from its constituents.

By such simple methods as these most inorganic compounds can be synthetically produced from elementary matter, but in the so-called organic chemistry it is not so easy to employ such constructive methods for the formation of compounds. Up to the end of the first quarter of this century it was supposed that organic bodies were only produced as the result of animal and vegetable life, and that their formation was due to the so-called "vital force," which was credited with governing all changes taking place in living organisms.

In the year 1828, Wohler showed that urea could be formed from cyanate of ammonium, while later on, Fownes made cyanogen by the direct combination of carbon and nitrogen, these two discoveries taken together clearly proving the possibility of forming an organic product from inorganic materials; and after this point had been reached, and the possibility of applying synthetic methods to the production of organic bodies had been demonstrated, compound after compound was built up without the aid of either vegetable or animal life, and the barrier between inorganic and organic chemistry finally broken down. Cases, however, in which such methods could be commercially successful were few and far between, as in most cases the processes which had to be adopted were costly and laborious.

In all the phenomena of ordinary combustion which we employ to provide us with heat and light, there are no compounds of greater interest than the class of organic bodies which, being formed of carbon and hydrogen in various proportions, have been termed hydrocarbons, and it is to this class of bodies that all the gases which can be used as ordinary illuminants owe their luminosity. Among the hydrocarbons, the simplest compound is acetylene, in which two atoms of carbon are united with two atoms of hydrogen; and it has long been known that, if a stream of hydrogen is passed through a globe in which the voltaic arc is produced between carbon points from a sufficiently powerful current, this gas is produced in minute quantities. It can also be formed in small quantities by the decomposition of carbon tetrachloride in the presence of hydrogen by the induction spark, while it is produced during processes of checked combustion in hydrocarbon flames. The direct combination of carbon and hydrogen in the electric arc is a true case of synthesis, and if we could form acetylene in this way in sufficiently large quantities, it would be perfectly easy to build up from the acetylene the whole of the other hydrocarbons which can be used for illuminating purposes. For instance, if acetylene be passed through a tube heated to just visible redness, it is rapidly and readily converted into benzol; at a higher temperature naphthalene is produced, while by the action of nascent hydrogen on acetylene, ethylene and ethane can be built up. From the benzol we readily derive aniline, and the whole of that magnificent series of coloring matters which have gladdened the heart of the fair portion of the community during the past five and twenty years, while the ethylene produced from acetylene can be readily converted into ethyl alcohol, by consecutively treating it with sulphuric acid and water, and from the alcohol, again, an enormous number of other organic substances can be produced. Thus acetylene can, without exaggeration, be looked upon as one of the great keystones of the organic edifice, and, given a cheap and easy method of preparing it, it is hardly possible to foresee the results which will be ultimately produced.

From acetylene we can produce all those bodies which we are accustomed to look upon as the most important ones in our coal gas, and which, up to the present time, have never been produced from anything but coal, hydrocarbon oils, or other organic matter undergoing destructive distillation, but it has often occurred to those of us who are interested in the manufacture of illuminating gas that, as the supply of coal gets smaller, and as oil in time begins to share the same fate, some new sources for our illuminants and our fuels must be sought; and in my mind, at any rate, the synthetic production of hydrocarbons has been a day dream, which I, however, never expected to see possible on a commercial scale.

Not only was the synthetic production of acetylene in the electric arc well known, but ever since water gas has been introduced, small traces of acetylene and methane have been found in it under conditions which render it impossible that they should have been produced from any compound present in the incandescent fuel. They must, therefore, have been due to the direct combination of carbon and hydrogen, but these traces only occurred in quantities so small as rarely to amount to one per cent., and it was manifest that the production of the compounds could not take place in large quantities under influences which would immediately tend to decompose them.

In 1836, it was found that when making potassium, by distillation from potassic carbonate and carbon, small quantities of a by-product, consisting of a compound of potassium and carbon, were produced, and that this was decomposed by water with liberation of acetylene; while Wohler, by fusing an alloy of zinc and calcium with carbon made calcic carbide, and used it as a source from which to obtain acetylene by the action of water.

Nothing more was done until 1892, when Macquenne prepared barium carbide by heating at a high temperature a mixture of barium carbonate, powdered magnesium, and charcoal, the resulting mass evolving acetylene, when treated with water; while, still later, Travers made calcic carbide by heating together calcic chloride, carbon and sodium. None of these processes, however, gave any commercial promise, as the costly nature of the potassium, sodium, magnesium, or zinc calcium alloy which had to be used made the acetylene produced from the carbide too expensive.

It is now some 25 years ago since I listened to one of the Friday evening lectures, at the Royal Institution, given by Mr. Greville Williams, and in the same way that the thread of some melody lingers in one's mind, so has the concluding sentence of that lecture constantly recurred with ever increasing force—"The impossible is a horizon which recedes as we advance; and the terra incognita of to-day will to-morrow be boldly mapped upon every schoolboy's chart." The haunting dream of the possibility of synthesizing hydrocarbons commercially has, with the onward march of science, to-day become an accomplished fact.

As is so usual in the history of discovery, the factor which has endowed us with the power of doing this was not the outcome of an elaborate research, having this discovery for its ultimate goal, but was found by chance during the search for another object.

While working with an electric furnace, and endeavoring by its aid to form an alloy of calcium from some of its compounds, Mr. T. L. Willson noticed that a mixture containing lime and powdered anthracite, under the influence of the temperature of the arc, fused down to a heavy semi-metallic mass, which having been examined, and found not to be the substance sought, was thrown into a bucket containing water, with the result that violent effervescence of the water marked the rapid evolution of a gas, the overwhelming odor of which enforced attention to its presence, and which, on the application of a light, burnt with a smoky, but luminous flame.

Investigation into the cause of this phenomenon soon showed that in a properly constructed electric furnace, finely ground up chalk or lime, mixed with powdered carbon in any form, whether it were charcoal, anthracite, coke, coal, or graphite, can be fused with the formation of the compound known as calcic carbide, containing 40 parts by weight of the element calcium, the basis of lime, and 24 parts by weight of carbon, and that on the addition to this of water, a double decomposition takes place, the oxygen of the water combining with the calcium of the calcic carbide to form calcic oxide or lime, while the hydrogen unites with the carbon of the calcic carbide to form acetylene, the cost of the gas so produced bringing it not only within the range of commercial possibilities for use, per se, but also the building up from it of a host of other compounds, while the production of the calcic carbide from chalk and from any form of carbon renders us practically independent of coal and oil, and places in our hands the prime factor by which nature in all probability produces those great underground storehouses of liquid fuel upon which the world is so largely drawing to-day.

Wonderfully and intensely interesting as is the train of thought opened up by the discovery of this substance and its commercial production, the object I have in view this evening is not to discuss theoretic possibilities, but to show you the important effect which it will have in the direction of our great gas industry, and the phase of this which I wish to deal with specially is the value of acetylene, either for producing, per se, an enormously high illuminating effect, or for the enrichment of low grade coal gas.

When the calcic carbide is placed in a glass flask and water allowed to slowly drip upon it from a dropping tube, the decomposition at once commences with considerable rapidity, and the acetylene pours off in a continuous stream; as the decomposition continues, the solid mass in the flask swells up, and is eventually converted into a mass of slaked lime.

Calcic carbide is a dark gray substance, having a specific gravity of 2·262, and, when pure, a pound of it will yield on decomposition 5·3 cubic feet of acetylene. Unless, however, it is quite fresh, or means have been taken to carefully protect it from air, the outer surface gets slightly acted upon by atmospheric moisture, so that in practice the yield would not exceed five cubic feet. The density and hardness of the mass, however, protects it to a great extent from atmospheric action, so that in lumps it does not deteriorate as fast as would be expected, but in the powdered condition it is rapidly acted upon.

For commercial purposes the carbide will be cast direct from the electric furnace into rods or cylindrical cartridges, which, when 12 inches long and 1¼ inches in diameter, will weigh one pound, and will give five cubic feet of gas.

The acetylene so made, when analyzed by absorption with bromine, the analysis being also checked by determining the amount present by precipitation of silver acetylide, gives 98 per cent. of acetylene and 2 per cent. of air, and traces of sulphureted hydrogen, the presence of this impurity being due to traces of sulphate of lime—gypsum—in the chalk used for making it, and to pyrites in the coal employed.

Acetylene is a clear, colorless gas, with an intensely penetrating odor which somewhat resembles garlic, its strong smell being a very great safeguard in its use, as the smallest leakage would be at once detected; indeed, so pungent is this odor, that it would be practically impossible to go into a room which contained any dangerous quantity of the gas.

This is an important point to remember, as the researches of Bistrow and Liebreich show that the gas is poisonous, combining with the hæmoglobin of the blood to form a compound similar to that produced by carbon monoxide, while the great danger of the latter gas is that, having no smell, its presence is not detected until symptoms of poisoning begin to show themselves, so that no fear need be apprehended of danger from this source with acetylene.

Acetylene is soluble in water and most other liquids, and at ordinary temperature and pressure—60° Fah. and 30 inches of mercury—10 volumes of water will absorb 11 volumes of the gas, but as soon as the gas is dissolved, the water, being saturated, takes up no more. Water already saturated with coal gas does not take up acetylene quite so readily, while the gas is practically insoluble in saturated brine—100 volumes of a saturated salt solution only dissolving 5 volumes of the gas. The gas is far more soluble in alcohol, which at normal temperature and pressure takes up six times its own volume of the acetylene, while 10 volumes of paraffin under the same conditions will absorb 26 volumes of the gas. It is a heavy gas, having a specific gravity of 0·91.

When a light is applied to acetylene, it burns with a luminous and intensely smoky flame, and when a mixture of one volume of acetylene with one volume of air is ignited in a cylinder, a dull red flame runs down the cylinder, leaving behind a mass of soot and throwing out a dense black smoke. When acetylene is mixed with 1·25 times its own volume of air, the mixture begins to be slightly explosive, the explosive violence increasing until it reaches a maximum with about twelve times its volume of air, and gradually decreases in violence until, with a mixture of one volume of acetylene to twenty of air, it ceases to be explosive.

The gas can be condensed to a liquid by pressure, Ansell finding that it liquefied at a pressure of 21·5 atmospheres, at a temperature 0° C., while Cailletet found that at 1° C. it required a pressure of 48 atmospheres, the first named pressure being probably the correct one. The liquid so produced is mobile and highly refractive, and when sprayed into air, the conversion of the liquid into the gaseous condition absorbs so much heat that some of the escaping liquid is converted into a snow-like solid, which catches fire on applying a light to it, and burns until the solid is all converted into gas and is consumed.

In my researches upon the luminosity of flame, I have shown that all the hydrocarbons present in coal gas and other luminous flames are converted by the baking action taking place in the inner non-luminous zone of the flame into acetylene before any luminosity is produced, and that it is the acetylene which by its rapid decomposition at 1,200° C. provides the luminous flame with those carbon particles, which, being heated to incandescence by various causes, endow the flame with the power of emitting light. The acetylene, being in this way proved to be the cause of luminosity, one would expect that in this gas we have the most powerful of the gaseous hydrocarbon illuminants; and experiment at once shows that this is the case.

Owing to its intense richness, it can only be consumed in small flat-flame burners, but under these conditions emits a light greater than that given by any other known gas, its illuminating value calculated to a consumption of 5 cubic feet an hour being no less than 240 candles.

ILLUMINATING POWER OF HYDROCARBONS FOR A CONSUMPTION OF FIVE CUBIC FEET OF GAS.

	Candles.
Methane	5·2
Ethane	35·7
Propane	56·7
Ethylene	70·0
Butylene	123·0
Acetylene	240·0

Having arrived at this startling result, it will be as well to at once turn to the commercial aspect of the problem, as it is upon this that the utilization of this magnificent illuminant is entirely dependent. At the present time, private information from America shows that calcic carbide can be produced at a little under £4 a ton, and the beautifully pure lime obtained by the decomposition would be worth to the gas manager at least 10s. a ton; and as a ton of the carbide will give rather more than 1¼ tons of quicklime or 1¾ tons of slaked like, £3 10s. may be taken as the cost of the acetylene produced from a ton of the material, and will leave a margin for handling. A ton of the carbide will yield in practical working 11,000 cubic feet of acetylene, which will bring the cost of the gas out at 6s. 4½d. per 1,000.

The cheapest and best enrichment process known at the present time is that introduced by Mr. Young, and which has been adopted at a number of gas works in Scotland and the north of England. In this process, by special methods of retorting, oils are decomposed to yield a rich gas, which, in the photometer, and burned in suitable burners, per se, gives an illuminating value of about 60 candles, but for which an enrichment value of 96 candles is claimed.

I am desirous of understating, rather than overstating, the powers of the acetylene, so that, instead of taking enrichment values for which it might be questioned, I prefer to simply take the illuminating power of the gas when burned, per se, and the light mea-

* A paper read before the Society of Arts, London.—From the Journal of the Society.

ured in the photometer, which, as before stated, is 240 candles, while, for the same reason, we will take the claimed enrichment value of the Young gas, instead of its photometric value.

An extended experience, gained with the Young process, as used at St. Helen's for the enrichment of coal gas, shows that the cost may be taken at 3s. 4d. per 1,000 cubic feet. If now we compare this with the acetylene at 6s. 4½d. per 1,000, we find that the 240 candle gas at this price would be equal to Young gas at 2s. 6½d. Moreover, the Young plant, to work a ton of oil per diem, costs—according to the experience at Peebles—£1,500, and generates 22,000 cubic feet a day, the retorts for this purpose occupying a very considerable space; while, to make the same volume of acetylene, two tons of material would have to be handled, and the whole operation could easily be carried out in one small egg-ended boiler, fitted with an automatic water feed and automatic gas delivery valve to outlet of the main for the holder, so that the enriching gas could be added pro rata to the gas as it left the works in order to bring it up to any required strength, in the same way as is done with the Maxim-Clarke enrichment, and all the troubles of stratification in the holder would be done away with. For the first few hours the water in the consumers' meters would absorb small quantities of the acetylene, but quickly becoming saturated, no further absorption would take place.

It is well known that acetylene forms two compounds with ammoniacal solutions of the metals silver and copper, and both of these compounds, when dry, can be readily exploded by percussion, friction or heat. In the early days of gas supply, copper pipes were used in New York, and Torrey, in 1839, found in them a brown scaly deposit, which exploded when struck or heated to 200° C., and which was, in all probability, acetylide of copper.

An extended series of experiments on this point show that when metals are kept in the gas, even if moisture be present, no action takes place unless water condenses on the metal, when tarnishing with silver and copper, and to a less degree with brass, commences, and under these conditions, an acetylide of mercury can also be formed, but the other metals remain unacted upon. If, therefore, iron, tin, lead or compo pipes be used for the gas supply, no precautions are necessary. Copper and brass tubes must either be coated inside with some varnish not acted upon by the acetylene, or tin lined.

In America, which was the birthplace of this method of making calcic carbide, the acetylene is mixed with an equal volume of air, and the mixture burnt at small slit burners; but I confess to a grave mistrust of this method of using the gas, as the margin of safety in the amount of air required to convert the mixture into an explosive is so small that the danger of exceeding it on any large scale must be very great, as any mistake or alteration in the mixing apparatus used for this purpose might easily bring the percentage of air up to the explosive limit, while the diluting action of the nitrogen of the air reduces the illuminating value of the acetylene present from 240 candles to 130.

The possibility of liquefying acetylene by pressures about those at which liquid carbon dioxide is produced so largely enables enormous volumes of this gas to be compressed into the liquid state in small wrought iron or steel cylinders, and in this condition, by means of suitable reducing valves and burners of the right construction, it may be stored and burnt. Used in this way, it will be of the greatest possible value for floating buoys, and the small cylinders can also be arranged in the form of portable lamps, while for use in the country, where no gas is available, a large cylinder of the liquid gas placed in an outhouse would supply a country house with light for a very long period; and there is no doubt that there is a very great field for it in this direction, as by utilizing suitable burners a consumption of half a cubic foot an hour will give a light equal to from 20 to 25 candles.

Perhaps the most valuable suggestion which has been made with regard to the utilization of this remarkable method of making acetylene is, that advantage should be taken of the method of preparation to utilize the body of portable lamps for dining and drawing rooms in places where no gas supply exists. To do this a strong steel cylinder, 4 inches in diameter and 16 inches in length, is fitted with an opening in the top of such size that a pound cartridge, or stick of the calcic carbide, can be passed through it. The cylinder has a second opening at the bottom, closed by a screw, for cleaning out the lime left by the decomposition. The right proportion of water is put into the cylinder, and the stick of carbide, coated with a slowly soluble glaze, is inserted and the head of the lamp screwed on. This head contains a double reducing pressure valve, which brings down the pressure existing in the cylinder to that necessary for the proper consumption of the gas, it also being fitted with a valve. As the glaze dissolves from the surface of the stick of carbide, acetylene is generated, and the five cubic feet are compressed by their own pressure, the cylinder being placed in a vessel of cold water while the gas is generating, and the gas can then be burned from a suitable jet at the rate of half a cubic foot per hour, which will give a light of over 20 candles for something like 10 hours. When the gas is all burnt out from the cylinder the top of the lamp is screwed off, the bottom plug also removed, and the lime washed out from the interior of the cylinder by a rapid stream of water. The cylinder is then recharged as before. Used in this way also, this gas would rapidly replace oil gas for railway lighting, as the fittings at present in use for the Pope and Pintsch systems would answer perfectly well for the purpose of using acetylene, the only difference being that the cylinder placed below the carriage, which, under the present conditions, is filled with compressed oil gas, would be utilized, not only as a storing, but as a generating vessel for the acetylene, the highly expensive oil gas manufacturing and pumping plant being done away with, and a magnificent illumination insured in the carriage.

Of late years, an idea has been slowly permeating the minds of some gas managers in this country that it might be well to adopt a dual gas supply, one for fuel purposes, which would consist of a poor coal gas of about 12 candles, while the gas for illuminating purposes would be of about 20 candles; and in one town, at least, it has been proposed, and, I believe, carried out, that a supply of poor quality coal gas should be sent out during the day, when the maximum consumption is for heating purposes, and a richer gas at night for illuminating purposes, utilizing the same mains for both. Although this is possible in a small town where the area to be supplied is not large, it would be impossible in a big town where many miles of huge mains have to be traveled before certain districts are reached, and the cost of a double set of mains would render a dual supply an impossibility.

The use of acetylene would render it possible for the gas company to send out a 12 candle gas for heating purposes, both by night and day, while a small enrichment cylinder might be attached to the gas outlet pipes from the consumer's meter, and this would be made to automatically enrich the gas supplied to his house, so that by setting a valve he could have any quality he might desire.

The economic value of an illuminant such as acetylene becomes apparent, when we compare the cost of the gas for equal illumination with the light obtained from other illuminants. The London gas has an illuminating power of 16 candles, while the acetylene has an illuminating value of 240 candles, and this, at 6s. 4½d. per 1,000, would in light-giving value be equivalent to London coal gas at less than 6d. per 1,000.

In order to obtain a given illumination, moreover, the volume of gas to be consumed is excessively small, as compared with any other illuminating gas, and the products of combustion are reduced to an excessively low limit. One hundred cubic feet of London coal gas will yield 50 cubic feet of carbon dioxide, and 140 cubic feet of water vapor, as the products of its complete combustion, while 100 cubic feet of acetylene would yield 200 feet of carbon dioxide and 100 feet of water vapor. The acetylene, however, in its combustion, gives a light of 240 candles, as against 16 yielded by the coal gas; and for equal illumination, therefore, the amount of carbon dioxide and water vapor produced is enormously smaller.

The following table contrasts the products of combustion evolved from London coal gas, when consumed in various forms of burners, and giving an illumination of 48 candles, which may be presumed to be the amount of light required in a fair-sized London dining room, and contrasted with this is the amount of the products of combustion which acetylene would evolve in giving the same amount of light; while to make the meaning clearer, I have added the number of adults who would exhale the same amount of carbon dioxide in the same time.

Burner.	Gas consumed.	Carbon dioxide produced.	Adults.
Flat flame, No. 6......	19·2	10·1	16·8
Flat flame, No. 5......	22·9	12·1	20·1
Flat flame, No. 4......	25·3	13·4	22·3
London Argand.......	15·0	7·9	13·1
Acetylene..............	1·0	2·0	3·6

If we obtained the same amount of light from paraffin lamps, the carbon dioxide evolved would be equivalent to 22·5 adults; while as far as carbon dioxide goes, you might as well invite 32·7 guests to dinner as use 48 sperm candles to supply the needed illumination.

The flame of acetylene, in spite of its high illuminating value, is a distinctly cool flame, and in experiments which I have made by means of the Le Chatelier thermo-couple, the highest temperature in any part of the flame is a trace under 1,000° C., while coal gas burning in the same way in a flat-flame burner the temperature rises as high as 1,360° C. If the heating effect of the flames be contrasted for equal illumination, it will be seen that the acetylene flame has so small a heating effect, considering its area, that it would not be much greater than the ordinary electric incandescent lamp.

The intensity of the light will make small acetylene lamps of enormous value for lantern projection, for railway signals, and, coming down to smaller things, bicycle lamps, while I should imagine the ease of production specially adapts it for such purposes as lighthouse illumination.

The scope and possibilities of such a discovery as that which I have brought before you this evening cannot be realized until many factors, at present unknown, are thoroughly worked out, and you must remember also that the time at my disposal has only enabled me to bring before you to-night some facts connected with the light-giving value of this hydrocarbon, and that, as a stepping stone to the synthesis of other bodies, its value will be incalculable. One cannot help feeling that as science grows, and as our grasp and comprehension of the marvelous processes by which nature builds up her matter become more and more extended, synthesis may have even greater conquests to make than the mere building up on a commercial scale of an illuminating hydrocarbon.

We are beginning to realize more and more fully the marvelous way in which nature keeps matter in circulation, the way in which animal and vegetable structures are built up from the simplest and most plentiful substances, and the way in which, when the structure is done with, those processes of slow combustion, which we call decay, again convert the waste bodies into carbon dioxide and water vapor, from which once more nature reconstructs the vegetable and animal kingdom; and it may be that as our perception of the methods of that marvelous natural architecture gets clearer and keener, we may discover how, by simple synthetic processes, the carbon dioxide and water vapor, which form Nature's building material, may be synthetically utilized by us in building up, not the perfected form of man, or animal, or plant, but the building on a commercial scale of the food which is required by Nature for carrying on the functions necessary for life.

DISCUSSION.

Mr. Lewis G. Wright said this paper was of much interest to technical men, in two points of view, because most of them had an interest in both the scientific and commercial side of any such process as had been described. He would ask whether it had been proved by experiment that the high luminosity of acetylene was retained when mixed with coal gas as an enricher, to the same extent as it showed when burned in the pure condition. Many, perhaps, might think that such would necessarily be the case, but he had reason to know that in mixtures of gases the luminosity was not always the arithmetical mean of that of the gases employed.

Mr. Wm. Sugg said the whole thing was so surprising that it was very difficult to offer any remarks upon it. He was much struck with the fact that this gas appeared to have such a strong affinity for oxygen. It was generally found very difficult, in burning a very rich gas, to provide it with a sufficient quantity of oxygen from the air to produce a brilliant light; but this appeared to burn as brightly almost as if it were in an atmosphere of oxygen. There did not appear to be anything very special about the burner, and, therefore, he gathered that the gas must have a powerful affinity for oxygen. The manufacture of the gas appeared so simple that probably most of those present thought they could do it straight off, but possibly some difficulties might crop up in practice.

Mr. C. C. Carpenter (Southwark and Vauxhall Gas Company) said he must congratulate Prof. Lewes on this sequel to his well-known researches into the effect of acetylene on the luminosity of gas. He should also like to emphasize the point raised by Mr. L. Wright with regard to the enriching power of acetylene. Another point which occurred to him was with reference to the production of the calcic carbide at the price mentioned. It seemed to him that that was very low for an article which could only be manufactured by the electric furnace, and he should be glad to know if any light could be thrown on the method of producing the electricity which formed the carbide. The whole thing hinged on the commercial aspect, and that depended on the cost of the material. At any rate, he thought Prof. Lewes had done something which would be a great relief to the electric light engineer, as he would be able to get a level load line by making an article which would serve for the manufacture of gas.

Mr. T. S. Lacey said many people thought the Young process should be more largely adopted by gas companies, on account of the cheapness of the gas produced; but with a rich gas, such as was made in London, the amount of enrichment was but a small percentage of the total value of the light, and that portion varied considerably. Sometimes you had to add one candle, sometimes two, sometimes half, and sometimes nothing, and the result was you were obliged to have a plant equal to the maximum enrichment, which was equal to the use of ten or fifteen per cent. of cannel; that meant a very large capital outlay. Any plan, therefore, which removed the necessity of such outlay was of great importance.

Mr. J. W. Helps said the paper had been very interesting, and he hoped it would prove of great value to the gas industry. Prof. Lewes said that acetylene would be used for enrichment much in the same way as the Maxim-Clarke process, i. e., it would be applied to the gas after it left the holders, and he should like to know if it would have any effect on the absorption of naphthalene, in which direction some enriching methods were found to be useful. He also thought the cost of the carbide was very low for an electric furnace product, and should like to know if the figures given were not based on electricity produced by water power.

Mr. Frank Mead said the paper had been quite a novelty to those connected with the gas industry, and was of intense interest. The main point, no doubt, in the commercial aspect, was the cost of the carbide. If it were produced as a by-product, one could understand its being sold at a low price; but could it be produced at £4 a ton if an electric furnace were employed for that sole purpose? If the process were generally adopted, the quantity required would be very large, and what effect that would have on the price it was rather difficult to say. This gas, when unburned, was said to have a remarkably unpleasant odor, which would make its presence evident, and prevent danger; but he would ask if there were any odor when it was burned. He did not see any reason why there should be an odor from its combustion, but the point deserved attention. Again, as there was a great difference between the specific gravity of this acetylene and that of ordinary coal gas, he thought there might possibly be layering of the two gases when mixed. The mixture with the gas as it went away from the holder was, of course, a different thing from mixing the enricher with the gas in the holder.

Mr. Frank Wright said it was very gratifying to find that electricity was, to some extent, trying to befriend gas, as in certain instances the reverse had been the case. He should like to ask Prof. Lewes if he had any information as to the candle power to be obtained by this gas per horse power of electrical energy, because, it seemed to him, it would hinge on that. If the gas companies did not take it up, the electrical concerns might work it round in a happy cycle of synthesis and analysis.

Mr. H. O'Connor asked what would be the effect of mixing acetylene with water gas. If it did not produce an explosive mixture, the smell given off by the acetylene might give to water gas the much needed quality of notifying its presence when escaping.

Mr. R. Manuel asked if there would be any danger of an explosion if an escape of acetylene took place in a room, and a person afterward went in with a naked light, and if so, would it be more severe than an ordinary gas explosion?

Prof. Lewes, in reply, said when he saw Mr. Lewis Wright get up, he fully expected to hear a question directed to some vital point. The question of enrichment was one of the most complex one could deal with, and enrichers varied to an extraordinary extent. An enrichment curve was never a nice, even curve, in which one, two or three per cent. increased the illuminating value in proper proportion. You always had a curve rather flat at the bottom, and then gradually increasing up to the proper point. He was at present working out the enrichment values of a large number of pure hydrocarbons and mixtures, and was gradually getting to the bottom of the secret, but those results must be reserved for another paper. He might say, however, that when acetylene was added in small quantities to coal gas, the enrichment value was about one and one-half candles per cent. at the bottom of the curve, and went up fairly rapidly until

you got to fifty candles, when it was at about its maximum. It was the same with ethylene, ethane, and several others. For water gas, however, it was of hardly any value as an enricher. If you took pure water gas, consisting of carbon monoxide and hydrogen, with small traces of impurities, ten per cent. of the acetylene mixed with it gave a non-luminous flame. He knew the reason of that, and it made it absolutely useless for the enrichment of gas of that character. The same thing was found by Dr. Percy Frankland with ethylene. The burning question, next to that of enrichment, was the price of the carbide. He believed the experiments quoted in America, from which the price of fifteen dollars was obtained, were made with electricity derived from water power; but there was another point to be borne in mind. Acetylene was not only a benefactor to the gas world, but it might be a benefactor to the electric world. The big installations which were erected for lighting purposes could only use their plant for about one-fifth of the day, and they were trying to make dividends in the face of that obstacle. They all knew what happened to plant which stood still for four-fifths of its life, and he ventured to think that when there was a market for calcic carbide many of the big producing stations would look upon it as a help rather than an enemy. If electric lighting were all in the hands of one corporation, they might think it worth while to try and stifle this, if they thought it was going, from its illuminating value, to interfere with them, but there were many corporations all struggling to show good returns, and if they could use the leads from the dynamos for an electric furnace during daylight and for the generation of light during the night, there need be no fear of getting a sufficient supply of electricity for this purpose at a reasonable price. In reply to Mr. Sugg, he might say that the luminosity of a flame was not due entirely to the affinity of hydrocarbons for oxygen; it depended on exceedingly complex chemical reactions, of which a few only had yet been thoroughly worked out; and, in fact, the acetylene flame, though so brilliant as to suggest the highest incandescence, was far cooler than that of an ordinary gas burner. The temperature of an ordinary sixteen-candle gas flame in some parts rose as high as 1,400° C.; but no part of the acetylene flame was much over 900° C. There was no overheating of the room, and the products of combustion were not noxious. If there were incomplete combustion, the flame would smoke so that you would have to turn it out, and with such incomplete combustion only would there be any smell. The products would be the same as from the complete combustion of coal gas—carbon dioxide and water vapor. The plan he should recommend in using acetylene as an enricher would be to introduce it by a regular flow into the outlet main. Mr. Lacy raised an important point with regard to enrichment. In London there was a monstrous waste of enrichment, and the gas was sent out considerably above the statutory limits in order to avoid any chance of a change of temperature bringing down the illuminating power, and so rendering the company liable to penalties. There ought not to be that necessity, and any process which required such a large margin was a wrong process. They needed that margin because they employed vapors to a considerable extent, and had to allow for skin friction in the mains, which was more important even than cold in bringing them out again. If acetylene were used, the gas might be sent out at 16·4 or 16·5 candles, and there would not be any chance of its losing its illuminating power, because they would be dealing, not with a vapor, but with a fixed gas. Acetylene would have no effect on naphthalene. The vapor of liquids had somewhat the solvent effect that the liquids themselves had, and that was why the vapors of some of the light hydrocarbon oils dissolved and moved on the naphthalene. He should put the relation between candle power and electrical horse power in this way: the light obtained from one horse power of electric energy, by means of an incandescent lamp, might be put at twenty-eight, and by means of the production of calcic carbide and acetylene at forty-four.

The chairman, in proposing a hearty vote of thanks to Prof. Lewes, said they were much indebted to him for showing how an ornamental gas works might be constructed, apparently at much less cost than the present structures, which by no stretch of imagination could be called ornamental. Another thing that struck him was that they seemed to be getting very near that great desideratum in electrical engineering, a level load line, by means of a new form of storage battery. The electric energy in the furnace came out in the form of a stick which could be carried about, and would give a certain quantity of brilliant light, whenever you put it into water; so that really it was a case of storage of electricity in an extremely convenient form. It appeared to him not at all impracticable that, after all, the best way of utilizing electricity would be to convert it into light by the method which had been exhibited that evening.

MECHANICAL BOTTLE CARRIER FOR GLASSWORKS.

How hard in some of its details is the labor of glassworkers, who are submitted to the high temperatures that are due to the large melting furnaces, is well known. So an endeavor is made to substitute well elaborated mechanical methods for manual labor, properly so called, in all cases where it is practicable. Thus, Mr. Houtart, a glassworks foreman of the North, who is at the same time a distinguished philanthropist, has just introduced into the equipment of ovens for annealing bottles an interesting improvement whose details have been communicated to us by Mr. J. Sagnier, a former student of the Central School. The process usually employed is as follows:

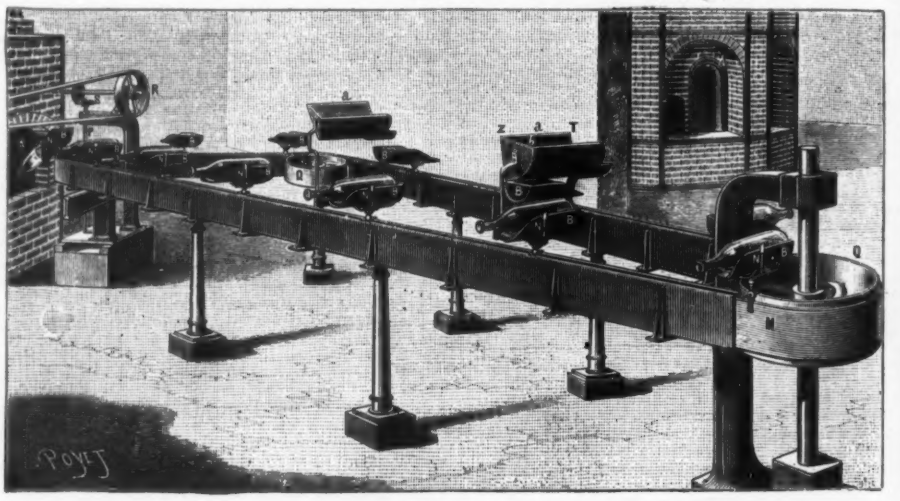
The bottles as they come from the hands of the blower must be carried to the annealing oven, wherein they cool slowly, else otherwise they would break. To this effect, they are, in the first place, arranged in an iron mould provided with a handle in the form of an iron rod. The office of bottle carriers is performed by children. Now, on the one hand, the new laws concerning labor render the recruiting of these children difficult, and, on the other, from a humanitarian view-point, these children perform an operation that has justly attracted Mr. Houtart's attention. In fact, while the blower is preparing a new bottle in the mould, the child must take away the punty rod that has been used in the preceding operation, bring a new cooled rod, introduce into the bottle mould a shaving of wood in order to prevent the bottle from adhering to the mould, and finally oil the pipe with which the blower shapes the bottle.

In the hot atmosphere of the works, the child who performs all these little operations goes and comes always on a run, shod with large and heavy wooden shoes in order to avoid wounds from the fragments of glass. After a good blower has blown his six hundred bottles in a day, the little carrier has made 1,200 trips, to and fro, between the blower and the oven, and has also taken away and brought back the punty rod 1,200 times, the total distance traveled in this hot work often being twelve miles. Grown up men themselves do not stand the work very well, and, what is surprising, not so well as children.

Nothing but a mechanical device could put an end to this hard labor. Such a one has been combined by Mr. Houtart, but it was not without trouble that he caused it to be adopted. It was necessary to struggle not only against technical difficulties, but also against an inveterate routine, the worst of difficulties. It was necessary in the very first place to render the continuous annealing oven practically utilizable, for, in the old way, a special annealing oven received and annealed all the bottles blown by all the blowers during the day's work; and every blower had his own unvarying station from which he could not be removed. Had the position of the annealing oven varied from day to day, it would have been necessary to have a mechanical carrier in attendance, as it were, every day, and to what an expense and complication that would have led may well be imagined.

The continuous annealing oven has, as we have said, caused this first difficulty to disappear. It permits of making use of a single oven and of a single mechanical carrier. The following is a brief description of it which our engraving will permit of being perfectly understood.

At aa, in front of each blower, there are iron plate receptacles lined with hard wood, in which the blower deposits the bottle that he has just finished. Beneath these holders pass receivers, BB, which likewise are of iron plate containing a bed of wood and which are set in motion by a belt, M, guided by a pulley, Q. The pulley, R, transmits motion through gearings, S, to another pulley, Q', back of the frame of the carrier.



APPARATUS FOR CARRYING BOTTLES TO THE ANNEALING OVEN.

The receivers, provided with a pendent rod, N, oscillate upon a pivot at right angles with their long axis. The rods holding the supports and connecting them with the belt, M, are guided by a steel cross bar which rests upon two cheeks, B, between which the belt runs.

The bottle is deposited by the blower at a. The side, B, of the holder, movable around a joint whose axis is ZT, is carried back to its normal position by a counterpoise. The receiver, B, passing beneath the holder, lifts the counterpoise. The side, T, opens and the bottle falls upon the wooden bed of the receiver. This bed inclines slightly backward, and the receiver is then able to pass under the other holders, a, without opening them. It continues on its way toward the point, A, situated opposite the door of the oven. Having arrived here, it tilts, carried along by the rod, N, and the bottle slides down an inclined plane and enters the oven in which it is to be annealed.

Let us add that a kick of an ingenious pedal by the blower greases the pipe through the intermedium of an oiled dabber, as was formerly done by a boy, and places automatically in the bottle mould the shaving of wood designed to prevent the melted glass from adhering to the iron.

Such are the results realized by this ingenious mechanical installation, which is to the praise of the glassworks foreman, who has prepared it by a profound study of every detail. It constitutes a short chapter in the protection of childhood in the laborious life of the manufactory, and will contribute toward preserving healthy and vigorous subjects for the industry without exhausting them at the period at which the human organism is developing, and at which it has special need of being spared. It is a useful and remarkable example of the application of machinery, which is too often called in question, with an absolute ignorance of the services that it must forcibly render as soon as any industry has reached a certain stage of progress and a limit beyond which primitive methods no longer assure either the requisite amount of necessary work or the just needs of the most elementary hygiene.—La Nature.

A NEW ELEMENT IN THE NITROGEN GROUP.

By A. E. TUTTON.

A NEW element appears to have been discovered by Dr. Bayer in the residual liquors derived from the older process for the extraction of aluminum from red bauxite, and an account of it is communicated to the current issue of the Bulletin de la Societe Chimique. The liquors in question consist chiefly of sulphate and carbonate of sodium, but there are also present considerable quantities of chromic and vanadic acids, and smaller quantities of molybdic, silicic, arsenic, phosphoric, and tungstic acids, together with alumina, magnesia, and lime, and an acid of the new element. In order to isolate the latter, the vanadium and chromium are first removed, the former as the difficultly soluble ammonium vanadate, and the latter as hydrated sesquioxide. The filtered liquid is then saturated with sulphureted hydrogen, and the sulphides, all of which are soluble in the alkaline liquid, are precipitated by hydrochloric acid. This precipitate exhibits a deep brown color, due to the new element. When dried it presents a brown earthy appearance, and burns readily with evolution of sulphur dioxide and formation of a bright brown powder. Concentrated nitric acid instantly causes ignition, and formation of a deep brown solution, from which a small quantity of a yellow precipitate of a compound of molybdic and arsenic acids is deposited. The brown liquid contains no tin, antimony, or tellurium, but still retains traces of vanadium, molybdenum, and selenium. These elements are best removed by calcination of the sulphides immediately after their precipitation with hydrochloric acid when selenium is volatilized, treatment of the residue with ammonia and ammonium nitrate, which precipitate the last traces of vanadium as ammonium vanadate, and concentration of the filtered liquid which causes deposition of ammonium molybdate. During the concentration two distinct crops of different crystals are obtained, the first and most sparingly soluble being cubic crystals of an olive-brown color, and the second the much more soluble ammonium molybdate. The olive-brown cubic crystals contain the new element, together with a little molybdenum. The latter is readily removed by dissolving the crystals in dilute hydrochloric acid, and passing a current of sulphureted hydrogen through the liquid heated to about 70°. The new element is not precipitated by sulphureted hydrogen in an acid solution. The filtered liquid is then allowed to evaporate in the air. At first it is bluish-violet in color, and contains the new element in a low state of oxidation; subsequently it becomes oxidized, and the color changes to lemon yellow. The oxide in the latter stage possesses marked acid proclivities, and probably corresponds to the formula R_2O_5. The acid itself is soluble in water, from which it is deposited in yellow crystals, which at a red heat fuse to a brownish yellow mass. Ammonia transforms the acid into a crystalline powder of olive color, presumably an ammonium salt, which readily dissolves in hot water and crystallizes from the solution in cubes on cooling. The solution is olive green, and is precipitated by strong ammonia. The solution of the acid after reduction with sulphureted hydrogen in presence of hydrochloric acid yields with ammonia a voluminous deep violet-brown precipitate, which rapidly becomes crystalline. The precipitation is not complete, hence the supernatant liquid is colored violet. Caustic soda and sodium carbonate likewise incompletely precipitate it, owing to solubility of the precipitate in excess of the reagent with formation of a soluble salt. Chlorides of barium and calcium produce grayish-violet precipitates of the salts of those metals.

An especially interesting reaction is that with ammonium sulphide, with which the highly oxidized yellow solution of the acid yields a deep cherry-red coloration, due to a sulfo-salt. Acids precipitate from this solution a sulphide of the color of iron rust. Silver nitrate produces a green precipitate of the silver salt, soluble both in nitric acid and in ammonia, and if the solution in the latter solvent is effected at a moderately elevated temperature, the silver salt is deposited in crystals upon cooling. Magnesia mixture gives, after standing a few minutes, a green precipitate analogous to ammonium magnesium phosphate, and, owing to the slowness of the precipitation, the latter occurs in the form of relatively large crystals; moreover, the precipitation is complete after a short time, for the liquid which at first is green becomes colorless. A yellow precipitate is likewise afforded with a nitric acid solution of ammonium molybdate, as in the case of phosphoric acid. The chlorides of the new element

appear to be volatile, for very considerable loss occurs on attempting to remove by ignition any admixed ammonium salts, for instance, from the solution obtained after removal of the vanadium as previously described. A yellow sublimate is produced having all the characters of a chloride of the new element, and which is readily soluble in water.

A sufficient quantity of the new element in the form of any of its compounds has not yet been accumulated to enable exact quantitative analyses to be carried out, but Dr. Bayer hopes shortly to have obtained the amount requisite for this purpose and for the determination of the atomic weight of the element. There appears to be little room for doubt that it will prove to be one of the missing elements predicted by Prof. Mendeleeff in the nitrogen-phosphorus group. It exhibits characteristic spectroscopic lines in the green, blue, and violet.—Nature.

DILUTED HYDROBROMIC ACID.

By CHAS. H. LA WALL, Ph.G.

DILUTED hydrobromic acid is one of the articles of the Pharmacopœia for which there is no official process of manufacture, although the Pharmacopœia fixes the standard of purity in a similar manner to the other acids. Notwithstanding the fact that diluted hydrobromic acid is not an article of every-day occurrence in prescriptions, this standard of purity should be as rigorously upheld as that of the more frequently occurring acids.

Some time ago the writer of this article had occasion to examine a sample of diluted hydrobromic acid which was known to have been made by Fothergill's process. The results of the examination were so widely at variance with the requirements of the Pharmacopœia that other samples were procured from various sources in order to ascertain the purity of the article as commonly found in the market.

Six samples have been carefully examined, all but one of which were from wholesale and manufacturing houses in Philadelphia. Not one of the samples tested complied with all the requirements of the Pharmacopœia, and while one or two approximated a state of purity, the remaining specimens were very impure, and showed evidence of very careless or faulty methods of manufacture. Free sulphuric acid was present in several of the samples (Nos. 3 and 6), an inexcusable contamination, and all of them indicated a higher percentage of absolute hydrobromic acid than is allowed by the Pharmacopœia.—Amer. Jour. Pharm.

GERMAN PRE-EMINENCE IN CHEMICAL MANUFACTURES.

PROF. W. OSTWALD, writing in the Zeitschrift fur Physikalische Chemie, states that some years ago he accidentally read that so-and-so many thousand cwts. of benzine, the chief part of the total national produce, were yearly exported from England to Germany. In itself this is only one number among many, but if such numbers are allowed to speak, they may tell us much. Benzine is not used as such; it serves for conversion into other substances, dyes, scents, medicines, etc. It is, therefore, an intermediate product, and we see here the remarkable spectacle that the oldest industrial country is compelled in the conversion of coal tar into the products above named to stop half-way and leave the most important and lucrative part of the manufacture to another nation. Further, England was the first country which undertook the manufacture of the benzine dyes on a large scale. What, therefore, are the causes which have led to this strange displacement? I found the answer on visiting England and studying the local conditions more closely.

In an important industrial city I visited a colleague who teaches chemistry in a local college. He showed me with pride his laboratory, which was in fact very beautifully equipped. But then followed the unavoidable query, "How many working students have you?" I will not here mention the number, but it was remarkably small in comparison with the total of students in the college. "Yes," said the professor, "my colleague on the other side has five times as many." It appeared that this other professor taught in his laboratory, not chemistry, but dyeing and tissue printing, and had consequently a great number of pupils. The young future technicist in England is too "practical" to study chemistry in its abstract form. If he intends subsequently to enter dye works, he studies dyeing. In Germany this is inverted; there every future technical chemist studies above all things chemistry; its applications follow afterward. The necessary result is that the English technicist must begin afresh if there occurs any important alteration in his department. The German falls back upon the general principles which he has assimilated and is quickly at home.

There is no sphere in which the superiority of our educational practice is shown so brilliantly as in technical chemistry. The laboratory of a chemical works that is on a level with the present day differs from that of a university only in being better equipped, and the researches there carried out are a direct continuation of the scientific investigations conducted at the university. This is the secret of the success of German industrial chemistry, the recognition that science is the best practice.

Prof. Ostwald sees one part of the evil, but not the whole. He had not the opportunity to observe how the time and the brain power of the English student are frittered away in preparing for examinations, and how the English professor is fettered by some syllabus which prevents him from teaching according to his own judgment. Nor could he see how the English manufacturer is hampered by our faulty patent laws.

HEAT STROKE.

SCARCELY a year passes in which, during the prevalence of the torrid temperature of summer, accidents of greater or less gravity, due to heat stroke, are not seen during grand reviews or in military marches. The men girt in uniform, loaded with somewhat heavy accouterments, and fatigued, now by a prolonged immovable station under the rays of a burning sun, and now by a hard and difficult march, fall in the ranks inert, forceless and faint. The accident is often averted, but has sometimes a rapidly mortal result. There is nothing more typical in this regard than the report of Surgeon-Major Roques on the accidents that occurred in the wake of a review at Longchamps in 1877. At the moment in which the legion of the gendarmerie mobile, leaving the field of review, was getting into the shade in the St. Cloud Park, a certain number of soldiers, and some of the most vigorous, too, were observed to fall upon the edges of the ditches. There was a brigadier who was livid, cold and pulseless and who stammered and had a haggard eye. A little care, some friction and some cold water revived him for an instant, but, a few minutes later on, he fell back unconscious and died in the carriage that was taking him to the hospital. A quartermaster, too, succumbed in a few instants and several men were afflicted with the same symptoms, but recovered their health at the expiration of a few hours or of a few days. The other troops did not, by far, exhibit such a morbid series, and the sorrowful event may be explained by the uniform of the corps, which was still wearing the tight stock around the neck. In the crowd of spectators, numbering more than five thousand, but lightly clothed, no serious accident was observed.

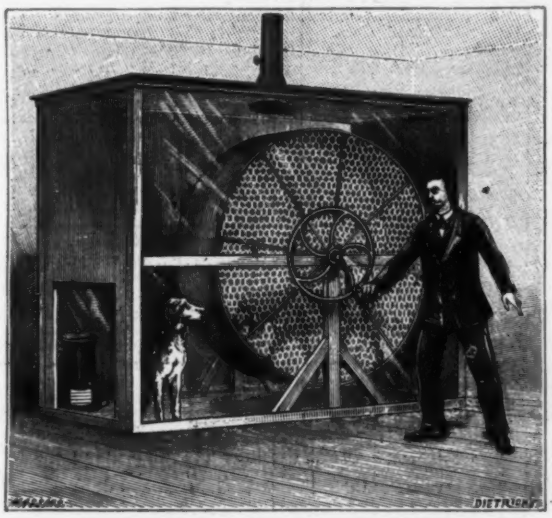
The troops employed of old for expeditions to hot regions frequently suffered heat stroke, until the necessity of dressing and equipping them in a manner in harmony with the rigor of the climate was understood. The helmet and the loose clothing of melton are now in ordinary use, but such was not the case at the epoch of the first French expeditions into Africa. In order to judge of the frequency of such accidents, one may refer to the memoir of Hiller, who found that in seven years, 773 men in the German army had suffered heat stroke, 116 of whom succumbed.

Heat stroke is not, as might be supposed, an accident due solely to the influence of solar radiation. It is, it is true, most usually a grave form of insolation, the result of summer heat, but it may be observed, and under absolutely identical conditions, in persons exposed to intense artificial heat. The stokers of steamers, shut up in the depths of the ship with excessive temperatures, are easily subject to this lesion, and we know that all the ships that cross the Red Sea during the hot season are obliged, for the maintenance of the fires and engines, to have recourse to colored men—negroes or Arabs, who are more habituated to supporting such temperatures, which sometimes rise to 70 degrees in the stoke holds. The stoker ascends half naked to the deck from time to time in order to get a few whiffs of air that is not so hot, and to revive himself and prevent suffocation. Similar accidents have also been observed in gas works, near the coke furnaces, where the heat is extremely intense.

The symptoms of heat stroke scarcely vary from one victim to another. Sometimes the fall is sudden, as in syncope. At other times, for short instants, there is a sort of vertigo, a heaviness of the head, and prostration. At this period aid may still prove efficacious. When the victim falls senseless, his face livid, his skin dry, and his eyes haggard, it is often the case that the progress of the symptoms cannot be averted. Convulsions and coma supervene, and if the internal temperature of the body be observed, it is seen to reach 39, 40, and, in some cases, as high as 45 degrees.

The pathology of this lesion is still much discussed. Claude Bernard thought that there was here a question of a direct action of the heat upon the muscular system, leading to the coagulation of the muscular fibers and in particular those of the heart. Others have prepared to see a sort of auto-intoxication by the products of combustion, which accumulate in the blood and are eliminated neither by the kidneys nor the skin. Finally it has been thought that there is a direct action upon the nervous system that brings on a sort of superexcitation, and then a rapid exhaustion. In order to elucidate this interesting question, Messrs. Laveran and Regnard have made a series of very curious experiments, the results of which they have quite recently communicated to the Academy of Medicine. Persuaded that solar heat or any sort of artificial heat was only the determining cause, and that a state of general fatigue was superadded, it occurred to them to put two dogs into a box heated at a progressive temperature. One of the animals was kept immovable against the side of the glass-fronted box and the other was inclosed in a wheel something like that of a squirrel cage, revolved by hand or by a mechanical movement. It was the analogue, in a certain sense, of the apparatus devised by Mr. Regnard for the study of mountain sickness. While the heat rose successively in the apparatus to 35, 38 and 40 degrees, and above, one of the dogs remained motionless, while the other, the one in the wheel, was forced to follow the more or less accelerated motion of the latter, and to perform a more or less laborious motive work. Now the following is what was found in these experiments: While the immovable dog supported, without discomfort, a temperature that rose from 36 to 46 degrees, the one in the wheel became very ill at the end of thirty minutes. Its rectal temperature was 42 degrees, it respired 200 times per minute, and the beatings of its heart were so rapid that it was impossible to count them. When, after half an hour, it was taken from the wheel, it gradually recovered, but when, on the contrary, the experiment was pursued or the temperature carried to 55 degrees at the end of the same time, the symptoms became still more marked and the dog died a few minutes after being taken from the wheel. The other dog, the one that remained immovable, had not yet suffered. At 60 degrees, both dogs succumbed, but the one that did not move resisted for several hours.

It results from these experiments that exercise and fatigue facilitate to a high degree the production of the symptoms of heat stroke. But this did not suffice; it became necessary to know whether such jading favored the accidents by increasing the internal temperature of the animal, and by preventing the elimination of the products of combustion through concentrating them, so to speak, in the economy and leading to an auto-intoxication. Now, the detailed researches of Messrs. Laveran and Regnard well prove that exercise under such conditions leads to a more rapid elevation of the internal temperature, but upon examining the state of the muscles of the heart, we see that it is not a question here of a coagulation of the muscular fiber or of a direct influence of the temperature upon the blood or upon the muscle. An analysis of the gases and of the products of the blood shows likewise that there is no deoxigenation, nor accumulation of toxines sufficiently numerous or active to give rise to grave accidents. There is, on the contrary, an excess of carbonic acid, whence a certain degree of asphyxia.



LAVERAN & REGNARD'S APPARATUS FOR THE STUDY OF HEAT STROKE.

According to Messrs. Laveran and Regnard, the most admissible hypothesis is that death is the consequence of the troubles of the innervation that are produced when the temperature of the internal medium exceeds 42 and 43 degrees and rises as high as 45, as has been found in some of those who have suffered heat stroke. There is at first an exciting action, and then a rapidly paralyzing one.

The conclusion that is clear from this interesting study of pathological physiology is that it is necessary to abstain, at least under ordinary conditions, from bringing soldiers together in the middle of the day during the months of strong heat, to order marches only for the earliest or latest hours of the day, and to space the ranks widely, in order to assure the men during the summer, and especially in tropical regions, an equipment in keeping with the temperature. These prescriptions have been for a long time in force in our army corps, and it will therefore suffice for surgeons of troops to see to the proper observation of them and to pay attention to the rules of hygiene, the best prophylactics of such accidents.—Dr. A. Cartaz, in La Nature.

THE OPTICAL EFFICIENCY OF COMMON SOURCES OF LIGHT.

CONSIDERING that the chief application of electricity at the present time is to lighting purposes, it is rather strange that there should be among electrical engineers so little accurate knowledge of the first principles of optics. Perhaps to this cause is attributable the fact that, while many engineers are occupied in improving, some 1 or 2 per cent., boilers, engines, dynamos and other plant for the conversion of forms of energy, up to the present time comparatively few have turned their attention to what apparently promises a far more hopeful field of research. Perhaps it is not inadvisable at times to remind ourselves how little real advance has been made in lighting matters since our fathers first adopted the rushlight for illuminating purposes. We have frequently had occasion to point out in these columns that, in view of the high efficiency to which boilers, engines and dynamos have now been brought, further economies in these directions do not present a very hopeful field for research, as there is no room for any very substantial improvement. On the other hand, the optical efficiency of

nearly all known sources of light is extremely low. By the term optical efficiency must be understood the ratio of energy expended in producing the sensation of light to the total energy dissipated in the lamp. The sensation of light is produced by such vibrations of the ether as are capable of affecting the retina—namely, vibrations having a wave length between 0·00081 and 0·00036 of a millimeter. The optical efficiency—energy expended in producing light—of the various common sources of light is, according to the latest determinations, as follows:

Oil lamp	0·073	per cent.
Ordinary gas flame	0·33	"
Incandescence lamp (electric)	1	"
Arc lamp	3·875	"
Magnesium light	15	"
Sun	31	" (about)
Geissler tube	32·7	"

The firefly or glowworm can hardly be described as common sources of light. Their optical efficiency, however, is so high that they are worth notice. The optical efficiency of the firefly is practically 100 per cent.; the whole of the energy expended by the insect in producing radiation being in the production of vibrations having a wave of such length as to produce the sensation of light. In view of the high efficiency, therefore, of this insect as a generator of light, a company which had for its aim the capture, sale and maintenance of fireflies for domestic purposes should be a profitable undertaking, if the first cost of the "generating" plant did not prove prohibitive.

It is worth noting that the greater part of the energy dissipated, in connection with the various artificial sources of light, in producing non-luminous rays, is expended in the production of vibrations having a wave length of about twice that of a vibration which produces the sensation of light. A very superficial examination of the many forms of lamps shows, however, that there is little hope for substantial improvement in the particular lamps in question. The light-giving powers of the arc lamp depend upon the degree of incandescence to which the carbons are raised. As, however, the crater of the arc lamp is close on the point of volatilization of carbon, no substantial improvement can be looked for in this source of light. The magnesium light, also, could not be made more efficient except under pressure, and the incandescence lamp is limited in its light-giving capacity for the same reason. The Geissler tube is so far ahead of all these other lamps as an illuminating source that the attention which has been turned to it by Mr. Tesla and others, with a view to producing a really practical lamp in this form, would appear to be well merited.—Electrical Plant.

SIBLEY COLLEGE LECTURES.—1894-95.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

FUNDAMENTAL PRINCIPLES OF BUSINESS: THEIR APPLICATION IN PRACTICE.

By T. DUNKIN PARET, of Stroudsburg, Pa.

IT is the rule for one who occupies the position of a recognized authority to quote only at first hand the authors whom he cites. If a position is to be defended—some old fortress of belief to be attacked—some advance of thought made—the soldier of scholarship must know just where his reinforcements lie, and summon by volume, chapter, verse, and line the supports on whom he depends. Nevertheless, every thinker, as he ripens in age and scholarship, fixes increased value on those settled convictions which are not traceable to volume, verse, or line of standard authority, which are not even the result of thoughtful deliberation, but which are the product of unconscious cerebration, digesting automatically the learning of others and the experience of one's self.

Among such convictions of my own is one, traceable to Herbert Spencer, in support of which I do not produce a single quotation. This conviction relates to the fact that the beginnings of knowledge are vague and obscure and that their progress consists in growing clearness of definition. In its most striking form this progress from the vague and obscure toward clear definition is the same as that which occurs in the opera glass, camera and microscope. Only because the use of these is so common do we fail to be startled by that miracle which one turn of a screw may effect; when the distant face speaks in recognized lineaments—the dull blot shines as tracery of flower, feather, or leaf—the expanded atom takes form as insect, microbe or seed. In its less striking form this progress relates to subjects of human knowledge, and to the human being as an unfocused instrument susceptible of infinite adjustment.

The appreciation of this instrumental possibility is so modern as to be an end-of-the-century one. To the age of the Greek philosophers, imagining so correctly the certainties which they lacked knowledge to verify, succeeded an age of dogmatists laying down as facts their incorrect beliefs about the world's uncertainties. Even fifty years ago the great bulk of human beings under tuition were brought up in the gloom and shadow of dogmatic belief; not as to religion only, but as to all knowledge; and were expected to accept fact and belief as matters of authority—of authority not to be questioned, appealed from, or even verified. The parent, the school, the church, the state—these asserted—it was for the young to accept and believe.

A modern writer (Mrs. Humphrey Ward, I think, in "Robert Ellesmere") has indicated, as one striking feature of the present day, an increased capacity to tell the truth. Her implication seems to be that this is a moral change; the product of an awakened conscience. But is it not, more probably, an intellectual result, based on increased ability to see the truth? Each more newly born youth is a more lately constructed instrument with finer appliances for vision and verification. With each clearer definition of the object arises the need for clear conception of the observed differentiation, and this need involves the further one for concise and exact expression.

Another female thinker (Mrs. Frances Hodgson Burnett, I think, in her novel, "Through One Administration") has shown how one suffering woman learned that ignorance received the punishment of sin. Is not this, also, an end-of-the-century appreciation? It is being borne in upon this generation, as never it was before, that in all the wide realm of universal law ignorance suffers the punishment of sin. There is borne outward the tendency to focus with clearer definition every sphere of knowledge—to conceive definitely extent and character of differentiation—to express accurately that which is conceived. There is a growing capacity to see—an increasing tendency to tell the truth. If ignorance is punishable as sin, then the hair line deviation from exact fact will bear with it its hair's weight of penalty.

Hence the modern rebound from authority—the tendency to question, appeal, investigate and verify. From old certainties rise new problems and we have an age, as Whittier says:

> "Where doubt looks out from star and stone."

And if doubt, then ignorance—if ignorance, then the penalty. At this doubt and ignorance are numbered, instruments are leveled and micrometer adjustment screws are slowly though eagerly turned. But in some spheres the methods of applied science are still new. The great thinkers of to-day approach cautiously those regions where the human and the inorganic come in contact. With evolution as it applies to the material world they tread familiar paths; but their walk is slow as they seek the genesis of human faculties; as they grope for the data of ethics; as they strive to penetrate the labyrinth of evolution, and study man in relation to his fellow man. Nevertheless, in almost every aspect man has been focused by some student—man as animal, as immortal being, as citizen, as parent—man in countless aspects. It is not evident that any one has made a serious study of man in his business life, or has tried to focus business life itself, and bring out from a vague obscurity a sharply defined entity.

When, therefore, the task was allotted me of addressing you in regard to "The Fundamental Principles of all Business and their Application in Practice," I responded that the subject allotted fell in line with certain meditations of my own, but that I might fail to treat it in the way expected. The request to lecture before a class devoted to exact sciences, the precise clearness of most of the title—such words as principle, fundamental, practice, application—these seemed to indicate a clear and precise subject, and to imply that, by just such exact method as a lecturer would use to instruct in building some special type of steam engine of given capacity, I was expected to instruct you how to succeed in business. If, however, business success is the sure result of certain rules and maxims, all you need is to scan the three line advertisements in the flash newspapers and send twenty-five cents in stamps for "A Sure Method to make $100,000 in Three Months, Without Capital," or adopt the still later expedient and take "Correspondence Lessons."

The key to our title is the word "Business," and this is as vague and obscure as the other words are clear and precise. In trying to focus business, the clearer definition brings out details and contours not suspected, and the treatment necessitated is one equally unforeseen by the allotter of the title and by the lecturer himself.

After a rapturous visit and generally gorgeous time, Daisy Angelica Jones informed her father that her late host and hostess, a newly married couple, kept their coachman and carriage and pair.

"But how can they afford it?" asked the older man.

"Oh," said the girl, with delightful vagueness, "I don't know, but it's all right; it's business, somehow!"

This beautiful simplicity exemplifies the state of mind of the young of both sexes before they are confronted with the necessity of self-support. Accustomed to unbroken daily comfort, parent provided, without explanation, children grow up without definite idea as to the difference between principal and interest; without conception of that great, but unknown factor, the earning capacity of the parent. Their lovely home is the slow accumulation of a lifetime's savings and the whole vested capital of a long worked parent, while the income which supports that home is a yearly salary. The children do not see why comfort should not always abound, nor why each of them cannot live apart in just such homes. Death sponges out the main factor, leaving a family without income and a home not divisible in salable parts.

The enlightened college provides no chair of domestic economy, and there are young lady medalists in the higher mathematics who cannot calculate the yards of carpet to cover a given sized floor; and young men who know the exact length of the River Yukon, but lack even an approximate idea of the length of father's purse. Girls grow up with the idea that, when a father fails to support them, a husband or a legacy will take the father's place. The boys have a vague notion that at some indefinite period they may have to enter business or take up a profession. It is doubtful whether any young person about to enter active life ever takes a deliberate survey of the whole field of business, or evolves a clear conception of the principles which govern it.

Such a survey might be attempted from the statistical side. In this study two text books would suffice—a volume of Dun's or Bradstreet's Weekly Abstracts and a compendium of our last census. In the former we have tabulated the probabilities of business life; that is to say, the number of insolvencies and the proportion of loss to total business. In the latter we have a numerical map which charts every industry. Here every calling is tabulated, and one can learn the capital, the number of laborers, the product. Here the localization of industries is clearly laid down, and none seeing it need engage in the profitless task of carrying coals to Newcastle. The more one studies this marvelous compendium, the more does he appreciate it as a great revelation. No longer, as he surveys these serried lines of figures, does he ask with doubt or sarcasm, "Can these dry bones live?" The facts become instinct with life, and business destiny, as determined by footed columns, seems a prophecy each young man can declare for himself. This he generally does, and without any study of abstract or compendium. He not only declares the prophecy, but seeks the destiny; and then, unexpectedly, bumps up against a lot of human attributes which stand between him and the figures.

In a minor novel of Dickens the hero is a dwarf, one of whose early eccentricities is his effort to secure a better appreciation of music by sitting on the top of a hand organ while a servant turns the crank. At a later period he becomes rich and goes into society. This he deserts after arriving at the conclusion to which his musical failure leads the way, that it isn't half so important for a man to get into society as it is for society to get into him. Probably many young men spend a long period entering upon and going through business and do not discover till after years of ill success that business has not got into them.

Almost every man begins his career as an employé, and there is often an employer who has certain old-fashioned notions as to what he expects of an employé. If the employé imagines that profound knowledge, wide range of information and brilliant suggestiveness are the things expected, he is much deceived. The first thing the old-fashioned employer looks for is accuracy. Accuracy of statement, of execution, of understanding, of observation. He does not want an employé who assents to his orders and goes off without really understanding them; nor one who brings him a garbled, slipshod statement about a business fact; nor one who cannot distinguish his inferences from his observations; nor one whose measurements need to be verified, and whose figures fall short of the standard applied to Cæsar's wife.

There is a feminine laxity of statement among many masculine men; they fire off statements at a fact as an inexperienced gunner fires a big charge of small shot, hoping that one may hit the mark. In the teaching of good schools fifty years ago, much was done to prevent and correct this habit. The study of grammar—even so slight a thing as Goold Brown's English Grammar—served to instill accuracy. Latin grammar, with almost mechanical adjustments and careful exercise in parsing—these taught strictness of sequence, the relations of the antecedent and the accurate fitting of one part of speech to another. Composition perfected the whole by developing the art of definite and correct expression. These niceties have fallen out of fashion. The student demands instruction in some specific branch, compressed in the least time and furnished at the least cost, that he may be immediately fitted for an immediately paying occupation. For the accomplishment of a mental habit, by which accuracy in all things can be attained, he has no time. The general trend of the period bends to his wish. The boy of ten or twelve, whose ear is quick to catch the telegraphic click and whose fingers are nimble to manipulate the keys, transmits messages whose weighty import prints no furrow on his brain. The telephone girl repeats with parrot-like insistence the information she cannot and does not want to understand. The stenographer and typewriter turn into human instruments, which perform their work with the same lack of interest and passion as do the writing pad and the key-struck ribbon. Above them stands that august being, the reporter, who claims for his petty and ignoble trade the title of a profession, and calls himself a journalist. From and through him exudes a perspiration of words which he mistakes for literature, and the hurried readers of great dailies and weeklies slip easily into his slipshod expressions, his newspaper English, his loosely fitting conceptions as to truthful report and accurate statement.

Unless the reporter has quite recently given us one of his small birdshot items, it has been reserved as a new departure for one of our foremost colleges to insist as a fundamental necessity of entrance on a sound general knowledge of English.

If this is so, what a satire it seems! What a mushroom growth of special and superficial acquisitions is indicated where there is no subsoil of substantial knowledge concerning the student's own mother-tongue.

Another thing which the old-fashioned employer looks for in his new employe is thoroughness. He wants to know that when a thing is done it is done. A higher authority than myself has so emphasized this quality that I need not dilate on it. In that well known historical personage, Sir Joseph Porter, K.C.B., Gilbert, the dramatist, has portrayed a character who climbed to the higher summit of position and whose ladder rested on the platform of thoroughness. This successful being began life by polishing up the handle of the big front door.

> "And he polished up that handle so carefully,
> That now he is the ruler of the Queen's navee."

George Herbert, a still older authority, exquisitely hinted at the same truth when he wrote:

> "Who sweeps a room as to the Lord,
> Makes that and the action fine."

Another thing which the employer looks for is a businesslike grasp of things. The correct synonym for businesslike grasp is common sense. By both these terms is meant a short, practical method of getting right at the point—a way that the old-fashined employer conceives as being quite different from the elaborate methods of students and learned men. Such an employer once welcomed to his office that great acquisition—a university bred man with the high training of a civil engineer. Naturally, there was some arithmetical work, and when the graduate brought whole sheets of foolscap, serried with figures, the employer looked wise and accepted the elaborate mystery as correct. Later, possibly owing to some doubt due to the employér's latent sense of proportion, that employer questioned as to the certainty of result. There was absolute certainty. The graduate produced a college textbook and referred to standard rules which were infallible. The rules were too intricate for the employer's brain, and the method so involved that he could not follow its thread of meaning and connection. He was able to demonstrate by a few figures on the back of an old envelope that the result was hopelessly wrong.

This same civil engineer was an excellent draughtsman and secured permission to draught the truss roof for a new mill. When the beautiful drawings were handed in the country carpenter had finished a truss roof of his own. To put the matter plainly, this college-bred man could not be trusted to do anything correctly or just at the right time. He and the other employés, whose youthfully impetuous knowledge was roughly grated by the appparently low-grade common sense of the employer, felt that facts and figures stood

in an unexpected way between them and business. It dawned on them that there were learned, elaborate, infallible methods whose result in their hands was failure; and curious little unsuspected by-paths which led straight to success. They couldn't see where the short cut diverged from the longer way, while the employer found it by what seemed an instinct, and which was a process of which he had formed no clear conception.

A more intellectual man once formulated this clearly. He was a man whose knowledge seemed profound; whose command of it seemed perfect. He exhorted a mere youth to adopt a certain profession and make himself an authority in it. "But," said the youth, "I haven't half your age, only a spark of your learning, and none of your genius." The older man replied that his ability did not spring from genius, but did rest on method; that variety and amount of knowledge were not so important as proper classification; that man was the most ready whose knowledge was divided, classified and arranged, like the druggist's goods, in drawers, bottles and pots, each kind by itself, with the location clearly in mind. It might be that memory alone, or the general law of mental association, would suffice to locate the chemist's drugs; but it would be surer and safer if all were arranged in an orderly and logical way. Thus should knowledge be distributed—well known facts kept separate from the probable but uncertain; simple things from complex. Thus should facts be arranged, like the chemist's drugs, so the student or the authority could pull out any drawer at will. Nay, once given complete method and logical classification, the young beginner could get along with a small stock, many bottles and drawers being empty, but strictly in place and ready to be filled at a moment's need.

To dispense this knowledge properly one must have the wisdom of right use. To rightly use knowledge, said this wise man, one must analyze, synthesize and strike out the non-essentials. In this sentence seems to lie the whole secret as to command of knowledge. Of the three, the middle process is the least important, for, if the facts are analyzed and the non-essentials struck out, the residue of dislocated joints will slip into their sockets with a click of satisfaction and accomplish their own synthesis. There is no quicker way of getting at the bottom of anything than by striking out the non-essentials, and if one begins his operations with this process, he grows astonished at the proportion of useless factors in every problem and at the clearance which a striking out of non-essentials involves.

Business men of an apparently low grade of common sense are often like the man who talked prose all his life without knowing it—they have carried on an intellectual process so complicated that they mistook its labyrinthine intricacy for simplicity. They have analyzed, synthesized and struck out the non-essentials, while they thought that the question had simply settled in their minds overnight. The employé, younger than the employer and better because later educated, grows quickly conscious of his own mental processes. Watching these, he becomes aware that many of his soundest conclusions are almost instantaneous and seem instinctive. He finds himself endowed with unsuspected facilities of quick detection and sure comparison; with certain new senses immediately perceptive of facts supposed to be discoverable only by careful calculation. He develops a sense of proportion so keen that it will discover a numerical error at a glance in the middle of page or problem without scanning that problem's course or result. He finds in his mind certain pockets of classification into which the balls of fact roll of themselves. This drops into the pocket of superficial area, that in cubic capacity; this into horse power, that into resistance; this into revolution, that into centrifugal force; this into expense, that into fixed account; this into repair, that into plant; this into cost, that into profit.

By the time he has got thus far, the employé has become an employer. Possibly he has clearly conceived this logical and condensed summary of "The Fundamental Principles of all Business and their Application in Practice." If so, he has only just arrived at the spot to first ask the question: "What is business?" But by this time, unfortunately, he has probably attached his honor and capital to some enterprise so weighty that it has anchored him for life. He is the head of some corporation with stockholders distant and unknown—stockholders having no human connection with the humanity of the corporation, and who look upon its employés and customers as mere coincidents with engines and machines in their work of dividend making. Or he may have tied up all his own savings and the loans of trusting friends in some real estate speculation, whose only chance of success depends on his permanent management. At this period, when almost hopelessly involved, he begins for the first time to study general conditions of business. Summaries, generalizations and principles attract him. He studies the Tribune's list of multi-millionaires and reflects on the origin and course of their vast and enticing fortunes. He picks up at random moments late editions of school and college text books, torn, scribbled and unappreciated by his own children, and wishes that he, when young, might have had their chances. Wishes that even now he might sit quietly down to study these books, and in so doing get rid of that rubbish of knowledge which the unanalyzing work of years has heaped up along with useful facts. For he realizes now that these text books are condensed compendiums of fact and principle. If now in some library he should see a gilt lettered title "The Fundamental Principles of all Business and their Application in Practice," he would seize that book greedily. Seize it, only to find that "The Fundamental Principles of Business" are not those in general use, and that others, like himself, drifted into business and are drifting through it. Such a text book ought to be compiled, and this, with another on "Domestic Economy," should be the gates through which every male and female graduate should be forced to enter life. A preparatory hand book should be in the satchel of every child at school. In this hand book the main object should be to make clear to every child the annual cost of his maintenance, the division of that cost under proper heads, and the proportion which his total bears to that of the family in which he forms a part. By such preparatory training the youthful scholar will be fitted for that more serious work on "The Fundamental Principles of all Business and their Application in Practice." Probably neither scholar nor student will take greedily to either text book. The precocious Mozart, who knows intuitively that his business is music; the Hercules-Apollo Sandow, who realizes that his business is physical perfection; these need no text book nor general survey to show them where their course lies. Behind these stands a class with faculties unformed, too doubtful to choose and not willing to stake their destiny on the footings of a tabulation. Back of these stands a third class in which at some time each boy has enthusiastically applauded the clown's profession and each girl selected as her throne the stool behind a candy counter. Which love, war, poetry, statesmenship, travel and a sequence of appearing and disappearing apparitions momentarily allure and repel. For these too early a final choice is unwise. If some years of experimental business were permitted, many would take up study again with new zest, learning in a week what formerly required a month, and emerging like trained athletes all ready for the business race.

Then would come the serious question, "What is business?" Then side by side on the desk would lie the text books on "Domestic Economy" and "Fundamental Principles;" the compendium of the last census and the weekly abstracts of Dun and of Bradstreet. Then would the student tabulate trades, examine the totals of various industries and study their localities. He will note their growth and estimate their proportion to the total demand. And he will be ready, in the cold glow of figures, to mortgage a future in which he does not discern the potent factor of his own and his brother's humanity. For these books—probably even the first edition of "The Fundamental Principles"—will cognize business only with a view to its immediate end, the acquisition of money—ignoring the object for which it is acquired and the investment and expense account, not pecuniary but human, by which this acquisition is secured.

Let us, too, ignore this question—for a time. Let us follow that course which is usual rather than that which is best, and leave to the last that matter which ought to be first—the moral significance of the business relation.

If the immediate object of business is to acquire the largest amount of money in the shortest time, several points have to be considered. If money is to be made by the sale of goods, then we have to decide between moderate business at fair or high profit and large business on a narrow margin. The latter involves large investment, expense, and risk. If much of the investment account is subject to interest, that item lasts through the dullest times, while general expenses admit only partial decrease. Slight changes of trade may depress that business below the paying point. If business be done on a five per cent. margin, some shrewd rival may save seven per cent. on his cost by secret process or published patent and wipe out your five per cent. profit. Or a changed tariff may suddenly enhance cost and foreign competitors invade your market. The elasticity of moderate business on liberal margin adapts it to a wider range of fluctuation.

The possibilites of demand call for close observation. Shall we sell a few articles of great cost or many articles of small cost? The invoice for a thousand ton hydraulic press will make a fine figure in the ledger, but think how few people want thousand ton hydraulic presses! Quill toothpicks might be a better business, for most well bred people use quill toothpicks. But think how many it would take to foot up the same cost as that of a thousand ton hydraulic press! On the other hand, the life average of a toothpick ought not to be more than a week—hence a large and constant demand. But a good press ought to last for fifty years. We have, therefore, to consider durability as well as first cost. The quill toothpick is not a finality, after all. Its probable average is a week, but the economical user might easily prolong this to a month, and so cut down the demand. Matches are better—the stingiest man in the world can't use a match twice. On further consideration, however, the match does not have so great an advantage as would appear. Every well-bred person needs a toothpick, for a toothpick is one of those things which not even the most altruistic man would dream of sharing with his neighbor. But the one match of a selfish man may light lamp or fire for a whole household. Hence a decreased demand for matches. We have carefully to consider the possible, probable, natural, cultivatable, and artificial demand. Wall paper of a definite price is within the range of a definite number of people. It is quite possible, therefore, that the maker of the most artistic paper salable at this price should secure the whole demand. It is probable, however, that he would get less than half, as cultured taste to appreciate his commodity would not equal uncultured love for gaudy and conventional show. The demand for candy seems to be a natural demand. The love of sweets is common to man and beast, and, by the variation of sweets under the form of candy, this natural demand may be fostered and stimulated till an immense industry results. No American city which does not boast its huge manufactory—no town which does not have its wholesale dealer—no cross-road store which does not display its fly-specked jar of spiral-streaked peppermint stick. The demand for chewing gum seems a purely artificial demand. No statue has yet been erected to the person who first discovered that the art of speech gave too little occupation for human jaws. Probably some aboriginal savage of Northeastern America found the exuding gum of a spruce tree adhering to his tomahawk and put it in his squaw's mouth to stop her too abundant speech. The speech was stopped, but feminine persistence kept up the motion of the jaw—the delights of chewing gum dawned on the female mind and the culture of New England made an American fashion of an Indian squaw's caprice. Probably no other article so well illustrates a cultivatable demand. The pioneer who first sailed on the sea of commerce with a cargo of chewing gum rivaled our Columbian discoverer. The first storekeeper who laid in a gross of the new article was a modern hero. The trade doubtless halted and languished till it struck a girl's school and then spread like wild fire. Nevertheless, its great development is a triumph of business skill. The trade flowed along in gentle ripples of tinted paper—it swelled into a freshet of perfumes—it overspread the land in a deluge of flavors, and it seemed as if full flood had been reached. Every healthy weakness of humanity was appealed to and yielded its percentage of sales. What more could be done? Why, the unhealthy was invoked. Tutti frutti gave way to pepsin, and the dead walls of all America beamed with the features of pepsin's great inventor—a rival to the cross-eyed visage of the three dollar shoe man. It was a grand success, and the tyro in business might well think that with wit, money and printer's ink, one could cultivate a demand for anything. And yet tyros have attempted this and failed. Not even a Boston exporting house can make Dahomey a live market for dynamos and palace car refrigerators, nor can the liveliest Chicago hustler tempt babies in long clothes to invest freely in stovepipe hats. If the seventy thousand pounds sterling per year of Pears' soap advertising were quadrupled, they wouldn't induce the baldest headed man to wear two wigs at once, nor would Rogers & Peet's most ingenious puffer persuade the deadest man to use more than one coffin plate. Attention must also be given to continuity of demand. In this respect the articles just named are safe. Neither the death of a czar nor the triumphs of a Democratic administration can greatly lessen the demand for wigs and coffin plates; but winter overcoats cease to sell in April and seaside hotels end their season at the first autumn northeaster. It would appear wise to choose objects just as standard as wigs and coffin plates, but commanding larger sale. Evidently people do not buy wigs and coffin plates with avidity as a matter of free choice, and some article of universal desire might be better.

Cloaks of real English seal are a good example. Every woman in America wants one of these. But every woman in America can't afford one, so the actual demand is moderate. Of those who do buy, the desire of some is so strong as to worry the money out of a submissive husband on a moderate salary. In this case he generally stops the amount out of his personal expenditures, thereby lessening his trade with other men to the amount of that cloak's value, and thus lessening to the same extent their potential ability to buy seal cloaks. Whereby, paradoxical as it may seem, undue indulgence in the purchase of sealskin cloaks cuts down the demand for such cloaks. Another bad feature about sealskin cloaks is that only full grown women wear them. Sugar, on the other hand, is consumed by man, woman and child, and nothing can be imagined surer to the tyro in business than sugar. Why shouldn't he open a store on the corner and sell nothing else? Unfortunately, sugar is too standard. Every grocer in town sells sugar, and will tell you he sells it at cost merely as a convenience to his customers, getting his profit out of something else.

(To be continued.)

[FROM THE SEATTLE POST-INTELLIGENCER.]

A WINTER VISIT TO MOUNT RAINIER.*

ST. ELMO'S PASS.

ST. ELMO'S PASS to the right appeared only 100 yards away, the clear air magnifying everything. The pass was named by Major Ingraham in the summer of 1887, when, accompanied by several mountain climbers, he camped there one night on his way to the summit of the mountain. Although it was a night in August, it was bitter cold and the party were threatened with being frozen to death. The major relates that during that night there was a thunder storm far below, and about 2 o'clock in the morning the wind having died down, the men reclined on the snow, wrapped in their blankets, endeavoring to sleep, when one of them shouted:

"The stars are coming out!"

Closer investigation showed that what they thought were stars were St. Elmo's lights on the ends of their pikes, which were sticking upright in the snow. Holding up their fingers, the light appeared on their finger nails, and then it was noticed clinging to the tin dippers which they carried along. Hence the place was called "St. Elmo's Pass." It is interesting to know that this was the first time St. Elmo's light had ever been observed on the mountain, and it was explained that possibly it was caused through the agency of the thunder storm which was observed at that time.

Almost before the party were aware, and by the time the snow cave was completed, the sun set. That evening's sunset was of a nature that would have made the heart of a Ruskin or one of the old masters beat with delight, for Ruskin has said that purple is the grandest and most inspiring of all colors. First the horizon was a deep red; then it changed to crimson, then to a resplendent royal purple, then to a light green, and all the colors intermingled for a few moments before the evening star appeared as a goodnight to the orb of day, and the darkness was upon the land.

Almost immediately the air became intensely cold and the men were driven into their shallow cave, while the wind increased in velocity and howled above and about them, and defiantly whipped drifts of light, icy snow into their rude shelter. The men remembered, as they rubbed their half frozen limbs, washed their noses in the snow, rubbed ice on their hands, to keep up their circulation, that it was the night before Christmas, and they began to wonder whether the delightful sensations of the expedition thus far had really repaid them for the hardship, cold and hunger incumbent upon such an experience. Before that dismal, long night came to an end some of them voted they were willing to mortgage their existence and forego all the pleasures of their experience for a mince pie, a fat turkey and a cup of red-hot coffee. They nearly perished with the cold, and when occasionally the wind would die down, and their bodies would accumulate a little warmth, the wolf of hunger would gnaw for something they did not possess.

There was no sleep that night, and at break of day the camp was deserted and the men struck out at a pace that soon warmed them up so that they hardly noticed the cold, though all were still hungry. They carried meat, both cooked and raw, but it being impossible to build any fire, the raw meat could not be cooked and the cooked meat was frozen as solid as icebergs and could not be eaten; consequently, the only edible articles in the whole outfit were seedless raisins

* Continued from SUPPLEMENT, No. 997, page 15941.

and hard tack, and these were neither desirable nor filling.

And this was to be their Christmas. How should they spend it? There seemed to be no doubt in the major's mind but that they should spend it in climbing, for after two hours and a half of steady marching, with a liberal use of the life line, the men succeeded in crossing Winthrop glacier and reaching St. Elmo's Pass, where another pigeon was liberated, bearing a message to Seattle, which arrived safely. It was released from an altitude of over 9,000 feet.

Crossing Winthrop glacier proved a hard morning's work for the already half exhausted little party. The constant caution that was necessary to keep from treading in a blind crevasse, whose opening could not be traced by reason of the newly fallen snow, and the great crevasses that were plainly seen and down which the eye could find no bottom, tried the men not a little. Dr. Lessey led the party most of the way, picking out the crevasses which could not be seen on account of the snow, and located the route in a zigzag course over the glacier. On several occasions the life line was all that saved the doctor from finding a grave at no one knows what depth, down a yawning, icy abyss. When the party reached St. Elmo's Pass they were in anything but good condition.

THE RETURN TRIP.

After the pigeon was liberated the climbers ascended to the head of Inter-glacier, reaching a height of 9,500 feet, which overlooked Blaine glacier and the entire east side of the mountain. Here the major halted. To the east the foothills of the Cascades were enveloped in snow clouds, which the wind was rapidly driving toward Mount Rainier, while further to the south the sky was overcast, showing that rain had set in on the levels lower down. From the position at the head of Inter-glacier the wind blew keenly and the men suffered almost as much there from the cold as they had the night before in the snow cave. The major stated that, while he had ascertained all that he had been sent for, and all that he had agreed to, he would proceed to the summit if the other members of the party desired to accompany him. He said it might be possible to go up 1,500 feet higher, but that the apparent broken and uneven condition of Blaine glacier would not permit the top of the mountain to be reached by that route. Blaine glacier stretched above and before them and did not present an inviting view. There were great crevasses, cliffs of ice, and mountains of snow with black basaltic rock mingling with the mass of dazzling whiteness, showing the route of recent avalanches. After some little hesitation part of the expedition declined to go higher, declaring that loss of sleep and lack of proper nourishment had left them in such a weakened condition that they did not feel equal to the emergency.

To have gone any higher would have necessitated the spending of the night in the wilderness of ice and snow on Blaine glacier, a prey to the howling elements, and the major, feeling that the experiment would be disastrous and probably fatal, ordered that the return to the foot of Carbon glacier be commenced. The downward tramp was quite easy, compared with the climb upward, and the distance of six miles, which going up had required nearly three days and necessitated spending two nights on the rugged sides of the mountain, was covered within seven hours, the men continuing to walk by starlight.

Before bedtime the men arrived at the camp from which the first view of the mountain had been obtained, and here they spent a very comfortable night, all sleeping soundly. Two days and a half later the expedition arrived home, all in good health, though somewhat bronzed and disfigured by reason of the hardships and privations endured.

THE PIGEONS.

During the tramp on the mountain, the sooing and cooing of the pigeons carried by the major was a source of much pleasure, sympathy and comfort to the men. The birds stood the cold splendidly, but it seemed that they could not get enough to drink. Part of the time the major did not wear mittens and the falling snow melting on his hands proved quite an attraction to the birds. First one pigeon and then the other would poke his little head from between the slats in the top of the box in which they were carried and would run his bill along the major's fingers, drinking the water made by the melting snow. It was also interesting to watch the birds drink whenever water was available. When the major discovered a series of warm mineral springs on the side of the mountain, he filled a tin cup with water and held it to the box. The pigeons do not drink like chickens or most other birds, but simply dip their heads in the water to their eyes and drink in swallows like an animal. The birds grew very tame from continuous petting and, when liberated, would decline to leave, preferring to remain near the box, not at all concerned about the movements of the men about them. The last three pigeons, which were liberated from Camp Mountain View, at the base of the glacier, were over an hour pluming themselves and cooing and talking to the major. It was finally necessary to drive them away. The three birds rose in the air, soared in circles several times and then darted away. Only two got home, the third one, bearing a message from the major to his wife, never being heard from afterward. It is possible that he fell a victim to some bird of prey while homeward bound.

During the twelve days the men were together they had ample opportunity for studying each other's characteristics, and it is an old saying that camp is the best place to find out a man's true nature. The six men who composed the expedition were a happy set of fellows. Hill, whose knowledge of cooking is unexcelled, generally volunteered to do most of this work, while the others divided up the numerous camp duties. All were willing to do all that was to be done. The expedition demonstrated one thing—that Major Ingraham is a most extraordinary man. He is capable of enduring excessive hardships and can encounter the most trying difficulties without losing patience or becoming discouraged. When he makes up his mind to do a thing he generally does it, if it can be done. He is a very quiet man—at times. During the first three days of the expedition he had very little to say, except to smile at the others' stories or jokes and applaud when some one, unable to contain his feelings, would break out in song. The fourth morning out, however, he broke the spell, and at daylight the men were terrified by a series of yells that would have put to shame a wild Apache. It was simply the major announcing the break of day. After that, every morning at sunrise the major's unearthly whoops, followed by the stentorian cry:

"It's daylight, boys! It's daylight!" was the signal for every one to brush the cobwebs from his eyes and get up. But as the party approached civilization the major grew very proud and longed to reach a place where he could sleep in a house on a bed. The last camp made was in the woods ten miles from Wilkeson, where a deserted cabin of a woodsman was located. In the cabin was a great fireplace, two bunks, a table and a floor of shakes. This was, indeed, a chateau de Frontenac in comfort and the place was called "Camp Comfort." There was something wrong about the place, however, for within ten minutes after the men had taken possession the major discovered a pane of glass in the single window of the cabin was missing, and he gingerly set about to find a board or a shake with which to stop the opening. Then the door to the cabin would not close, and he created consternation by saying that rather than sleep in such an open place he would camp on the trail. But he did not carry his threat into execution. A feast for the gods was here prepared and a big log fire burned all night, warming the cabin thoroughly and insuring a good night's rest for all.

Although throughout the trip the major kept up his reputation for remarkable good nature, there were several times when he gave way to fits of anger, but on these occasions he was quite excusable. Now if there is anything under the sun that he seriously objects to and abhors, it is swearing, and only twice during the whole expedition did he permit "cuss words" to pass his lips, which is more than one or two of the other members of the party can say. On the second day's tramp down the river, when the men were headed homeward, the major, with his blankets on his back, a camera strapped around his neck, a couple of canteens hanging to his waist, a big pair of field glasses dangling low and bumping him on the knees at every step, and the empty seven-foot toboggan under his arm, endeavored to ford the river at a sharp bend without the painful necessity of wading in the icy water. He carefully stepped from one rock to another, until he landed on a big smooth stone in the middle of the river. The surface of the stone was barely washed by the rushing, seething stream and was so slippery that the major could not get a safe foothold, and the capers he was compelled to cut to keep from sliding off the rock in the water would have insured him a position among the tumblers in Forepaugh's circus. He had no idea of getting a ducking, and, seizing the toboggan in both hands and pushing it from his body, he whirled around and around as if he imagined the toboggan was his partner in a prize waltz. Every time he would bring his foot down on the rock it would slip off, and then he would spin around, the field glasses getting tangled up with his legs, the canteens beating a tattoo on his ribs, and the camera giving a foul punch below the belt at every jump. Finally he succeeded in getting a foothold on the rock, and his face was wrinkled and seamed with justifiable rage. He had his mouth puckered up for a cuss word as big as a house, but when he saw the rest of the party grinning in great amusement at his discomfiture he forced a smile, and, assuming a position like a rooster preparing to crow, he vehemently declared:

"I'm not a fool! I'm a crank; that's all!"

On one other occasion the major was deeply vexed. When nearing Wilkeson he believed that he came upon the almost obliterated trail leading down the hillside along the river. He plunged into the woods, following the trail, dragging the cumbersome toboggan after him, the rest of the party following. After half an hour's laborious encounter with all manner of bramble bushes and climbing over fallen trees, the trail led straight up against the face of a bluff that could not be scaled. Then the whole party was mad. The major sat down on a log, and alternately hit the toboggan with his fist, as if that inoffensive piece of furniture was responsible for the mistake, and tore his hair. But he did not swear. The others were performing that part of the programme with great elegance and finish and he probably felt the necessity of setting his younger companions a good example.

After leaving Camp Comfort, the trail leading to Wilkeson, now only ten miles away, was very plain, and each one set out for himself, all eager to reach civilization. Boyd's feet were very sore, his shoes having worn out and his toes were protruding from great rents in the leather, as if they were desirous of viewing the country through which their owner was traveling. He made no effort to keep up with the rest and continued lagging until he was about a mile behind. When the leaders arrived at Wilkeson, Boyd was not in sight. An hour passed and he did not arrive. Two hours went by and still no Boyd, and the major was seriously considering the advisability of sending out a searching party, but about this time the tall form of a ragged, dusty individual carrying in one hand a rifle, an alpenstock in the other and having a pack on his back, hove in sight down the railroad track, approaching from the direction of Carbonado Around and about him the air appeared blue and murky, and on his near approach the children and timid natives took to the woods.

Boyd had come to a place where the trail branched, and, taking the wrong one, went to Carbonado instead of Wilkeson, which necessitated an additional walk of about five miles before rejoining his companions.

Dr. Lessey proved himself one of God's noblemen; always ready and willing to do all the work in sight, and his merry "all right" to every move proposed will long be cherished by his companions on this trip. It seemed impossible to propose anything that he would not immediately accede to, no matter whether it caused him inconvenience or not. At Miner's Camp, when the mercury in the thermometer was playing around in the vicinity of zero, the doctor was seized with the insane idea that if he had a bath he could travel easier, and so he immediately stripped to the waist and ran down to the river before breakfast and proceeded to make himself familiar with the water. He came back in about five minutes nearly frozen to death, just as the major was preparing to photograph him, having in mind a cut to be presented to the readers of the Post-Intelligencer labeled, "Rainier baths." The major suggested that the doctor go back and do it over again, so that he could place the photograph in his private collection. Lessey said "all right," though with some hesitation, and he trotted back and once more showered the icy water over his body. This second experience was too much for human endurance, and two members of the party devoted the next half hour to bringing him around by rubbing him down, thus aiding the circulation. Unfortunately the photograph refused to develop and the major did not get the picture to place in his private collection after all.

When the party arrived at Wilkeson on the following day they were a hard-looking set, and there appeared a disposition on the part of the landlord of the hotel to show the guests to the cellar, but he finally admitted them. A bath and supper improved appearances and all retired early.

When day dawned, the doughty major awoke suddenly; and thinking he was still in the mountains, gave vent to his accustomed woodsman's yell. The noise awoke every one in the house, and the startled landlord was soon in the hall with a frightened look on his sleepy face, very little on his body and a shotgun in each hand. The major did not repeat the offense and no one knew who the guilty one was, but the landlord swore he would lick the man if he discovered his identity.

Seattle was reached the same morning, and the men looked like Ward McAllisters compared with their appearance on the occasion of their arrival at Wilkeson the previous day. The return homeward was the signal for an enthusiastic reception, and the event of the expedition will be an epoch in the lives of the explorers which will never be forgotten.

(To be continued.)

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